Windows as Environmental Modifiers in Lebanese Vernacular Architecture

Habib Melki – Senior Lecturer

Notre Dame University, Faculty of Architecture Art & Design
P.O. Box 72 Zouk Mikael, Zouk Mosbeh – Lebanon
E-mail: hmelki@ndu.edu.lb; hshjjmr@terra.net.lb

ABSTRACT: Windows in Lebanese vernacular buildings were sized and placed proportionally in order to allow the required amount of light and air circulation for comfort. The aim of this study is to explore the evolution of the window in Lebanese vernacular architecture with respect to typology, functions, environmental features, methodologies in construction and cultural features. It will include a comparative analysis of different typologies in respect to ventilation, daylighting, heat transfer, acoustic barriers, etc.

Keywords: Windows; Vernacular Architecture; Daylighting; Ventilation

1. INTRODUCTION

Lebanese architecture was greatly influenced by the abundance of stone which offered the opportunity for good masonry construction. This produced families of stone-masons who passed on their accumulated skill from generation to generation, evolving a mastery and tradition of design in stone which is largely responsible for the homogeneous character of Lebanese architecture. Windows, a major detail of this construction, were meticulously placed according to sun orientation, topography, wind patterns, views, and socio-cultural aspects.

Windows are the least effective heat flow inhibitors of a building's shell, both in terms of letting heat out in the winter, and letting heat in during the summer. The evolution of the window in traditional Lebanese architecture shows an evident change in size, form and function. The factors that affected its evolution were not only due to technological development but also to cultural and social standings of the different classes in Lebanese societies. This progression in window typologies was clearly reflected in larger cites like Beirut, Tripoli and Sidon. The wall treatment in area (wall to window ratio), thickness and material, remains the primary element that evolves with the change of the window. Windows were minimized to be consistent with interior requirements and were recessed. Different dimensions of openings were made to provide proper cross ventilation and benefit from the prevailing summer winds.

2. CLIMATIC ASPECTS

According to the UNDP Thermal Standards for Buildings in Lebanon, climate in Lebanon is characterized by the existence of a cold winter season (January - March), a hot summer season (July - September) and two mild mid-seasons (April - June and October – December).

The diverse topographic characteristics of the regions result in different site-specific situations. The configuration of hills and valleys affects the orientation of the sites with respect to the sun, the degree of relative humidity as well as the wind direction. In these configurations, the wind direction flows from the coast into the valley in the daytime and does the reverse at night. Consequently, all the sites flanking the valley have particular wind flow patterns depending on location, altitude, and time of day.

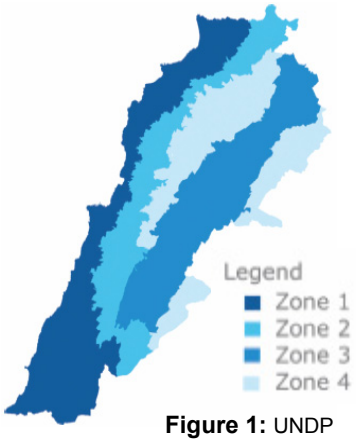


Figure 1: UNDP

The following is a selection of climatic charts representing overall climatic trends in the different climatic regions.

LEGEND	CLIMATIC REGIONS	MINIMUM TEMPERATURE	MAXIMUM TEMPERATURE	RELATIVE HUMIDITY
ZONE 1	Coastal region	7°C-16°C	24°C-32°C	60% to 80%
ZONE 2	Mid-mountain region	0°C-15°C	16°C-28°C	40% to 60%
ZONE 3	High-mountain region	-7°C-10°C	15°C-30°C	50% to 90%
ZONE 4	Inland region	-5°C-15°C	15°C-40°C	30% to 75%

Table 1: UNDP Thermal Standards for Buildings in Lebanon

3. SOCIAL, CULTURAL AND ECONOMIC FACTORS

Throughout history, Lebanon was the crossroad of a variety of cultures and civilizations. These currents coming from the East and West carried new forms; concepts merged with the local tradition to unfold what we currently know as Lebanese architecture. New technologies and socio-cultural aspects copied from the West mixed with the Arab identity to contribute to the change and development of the Lebanese identity in architectural forms. *(Liger-Belaire, 169)*

The evolution of the Lebanese society and the definitive classes was directly translated into the architectural language. The poor continued living in the simple cubic structures, with minimal decorative window features, while the rich, depending on financial and social standings, occupied the "Beirutie" House (middle class) or the mansion (high class). The arch-shaped windows and the introduction of columns in the configuration are indications of Roman, Italian and Venetian architecture at different intervals of time. Whether through conquerors, artists or architects invited by the Emirs, new trends, forms, and decorative patterns were introduced and added to define the typical Lebanese style. With the spread of Islam the concept of protecting the woman from outsiders introduced the "moucharabieh" and reduced the size and number of windows. The Roman arched window borrowed new features from the Islamic style and became the pointed arched window, a particularity of Lebanese architecture *(Sehnaaoui, 85)*.

During the second part of the 19th Century, as major cities in Lebanon especially Beirut became trade centers, the presence of foreigners living on a permanent basis revolutionized the concept of the window. The small protective character gave way to the big exposing window not only to see but to be seen. The new facades with large openings giving a view towards the sea or the street were definitely an evident rupture with the past. The triple arched facades were an indication of the appearance of a new social class: the trade bourgeoisie. Although different religious groups had their own preferences in architectural styles, ornamentation was used depending on its originality and innovation. The use of glass in Lebanon was mentioned for the first time by H. Guys in 1847 and clearly indicated that it was solely found in rich houses. Boyer describes these facades as being oriented in the direction of the main street or opened to a garden or a court, supported by white marble columns with meticulous details in the wood work and the occasional use of colored glass which made the window a real piece of art *(Sehnaaoui, 85)*.

The design quality in composition, detailing and the amount of ornamentation, reflected the wealth of the individuals as well as their social standing. On the other hand, with the spread of rental houses, this phenomenon expanded downward since moderate-coast construction was needed and the master builders were able to assimilate the wide range of ornament vocabulary. Mass produced ornamentation and spontaneous collage of different elements slowly replaced the elaborate, refined and unique designs *(Saliba ,42)*.

4. WINDOW TYPOLOGIES

After the mid 20th Century, Lebanon witnessed a gradual disappearance and dissolution of vernacular structures. A closer study of these dwellings, even in their most modest existence, may highlight the variation of different window typologies in Lebanese architecture, and their details, ranging from perfect adaptation to site, intelligent use of local resources, energy efficient structures and adaptation to the climate.

4.1 Rectangular Windows

The rectangular window is the simplest and most common. It changed throughout the history of Lebanese vernacular architecture being affected by environmental aspects in all four climatic regions and stylistic foreign influence particularly in Beirut. Used in all house typologies, the rectangular window evolved from a small, thick and roughly constructed opening to an elaboration of ornaments and fine details.

Figure 2: (Corpus Levant)

The oldest window-shaped opening recorded in Lebanese history goes back to prehistoric times, where natural caves were enclosed to create living spaces (Troglodyte house–figure 2). A masonry wall (barrier 80cm thick) made of dry stacked stones was elevated up to a certain height controlled by needs of defense, natural light and ventilation. Additional openings were dug in the mountain for cross ventilation purposes, especially for deeper cells or living units. Orientation was dictated by the natural setting of the caves. This typology evolved into a primitive form of seasonal housing, mainly for cattle and sheep breeding, characterized by its cylindrical shape with the main entry (low door) positioned to avoid dominant winds and one rectangular window (80x80cm). A more elaborate and permanent form of vernacular architecture, located in all regions, was the rectangular house.

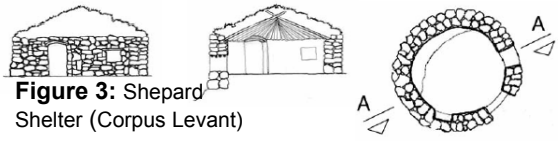


Figure 3: Shepard Shelter (Corpus Levant)

The closed rectangular house is the simplest type of flat roof houses dating from 5000 years BC. The rectangular house window was defined by the thick masonry walls (50-100 cm which

included niches and storage areas) and limited in number and size according to location within the climatic regions. Lintels were made of monolithic stone blocks or wooden juxtaposed elements. No protrusions were evident and smaller openings located above these windows (below the roof) served as ventilators (closed during winter). Deciduous trees and scaffoldings that support deciduous vines were another way to block sunlight in the summer and admit sunlight in winter until early spring. Overhangs were later introduced as shading devices in the hot summer and to keep rain water away from the walls and windows.

The thick, sometimes tapered, walls were carefully designed to shade the opening during the summer but not block sunlight during the winter. The use of movable outside wooden shutters was also a means of shading. The orientation of these windows followed the natural setting since integration and minimum excavation ruled the positioning and the shape of the house.

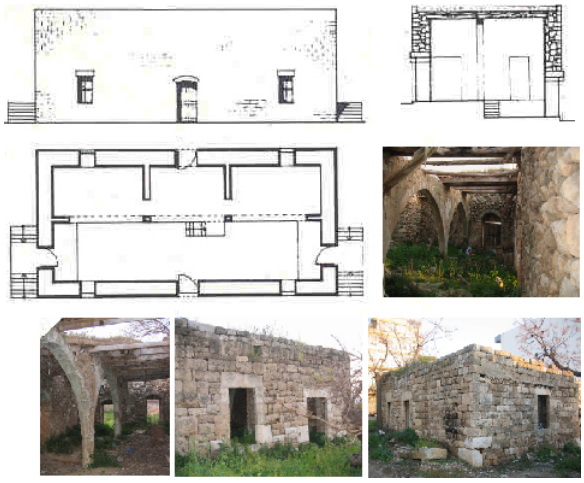
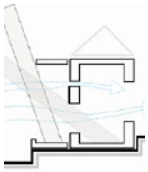


Figure 4: Rectangular Typology (drawings by Ragette, 19).

Depending on the climatic regions, openings in rectangular houses differed in size and location. On the coastal region, where solar gain and humidity are factors to consider, windows are places were maximum ventilation can occur in contrast to the high-mountain region where window size and number is kept to a minimum. North-side open-space is usually rendered for outdoor summer activities during the day in all climatic regions.

Whereas in the inland region, window openings seldom occur due to the characteristic feature of grouping houses therefore minimizing external climatic exposure. In the Beqa'a, the grouping of closed rectangular houses predominates; the detached house is rare *(Ragette,22)* . Also in the high-mountain, region variations of reducing heat loss conditions in north walls include backing the building into a sloped hillside or providing a berm (the level area separating ditch from bank on a hill-fort or barrow), both of which reduce the exposed north area to cold winds and heat loss.

The development of this typology of Lebanese houses focused on two major architectural features in relation to the environment: view and protection from undesired climatic conditions (sun and rain). As stated before, summer outdoor activities focused on the north open-space that rendered dominant orientation of the "gallery" towards the north, when possible, and towards a valley gaining the pleasant breeze for natural cooling. The gallery was designed in such a way that it served as a solar screening device during the summer and a solar gaining area during the cold seasons while keeping the house circulation area protected from the rain.



Whether single or a double floor, openings existed in large sizes in walls of less stone thickness (40 – 50 cm). Smaller openings were placed above or adjacent to the larger windows that served for ventilation and natural light access during the cooler seasons or when the house was not occupied. Lighting accessories, lamps, candles, etc. had special small niches on both sides of the wall that lit and highlighted the riwaq during the evening. The placement of windows is mainly within the riwaq taking advantage of the shaded area as well as the cross ventilation caused by the openings on opposite sides of the rooms. This gallery is known for its social family activities during the mild and summer seasons. It also served as the connecting passage of the house. It must be greater in length than in depth and must serve several rooms and be connected to the entrance of the house; the height is the same as that of the rooms which is about 4 to 5 m. *(Ragette, 39).*

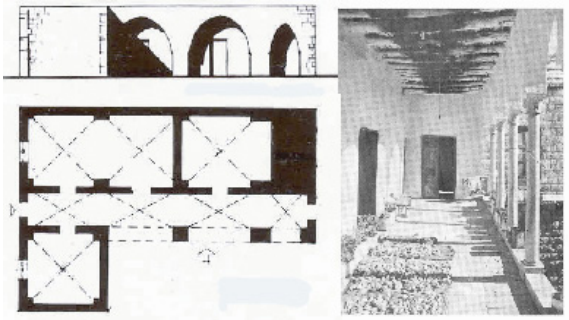
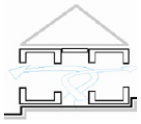


Figure 5: Gallery Typology (Ragette, 19).

Figure 6: Gallery Typology (drawings by Ragette-19, photos by Corpus Levant & Kassatly).



The liwan is a space that opens to the outside and continues by connecting to the space in front of it *(Ragette, 68).* Seldom found in the high mountain region, the liwan is a space used for circulation, social activities and storage space which is covered but always open to the outside. Cross-ventilation was achieved by internal windows or vents between the rooms and the central space, which originally was permanently open. Furthermore, the very position of the central living space, be it the liwan or the central hall, ensured that it is the coolest space during hot daytime. Shielded on its long sides by the adjacent rooms, the open end of the hall was either turned to the north or to the south in order to avoid deep penetration of the sun's rays. Color played an important role in the cooling of structures. Light color material was applied on exterior surfaces reflecting excessive heat during the hot season as well as on interior barriers in order to maximize the usage of natural lighting. Other criteria that played a role in selecting the position of the openings were: views, natural lighting and privacy requirements.

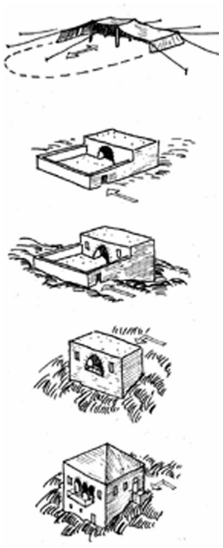


Figure 7: Evolution of the liwan. Ragette, 88).

The construction is usually bearing walls composed of two ashlar stone faces and a rubble core measuring a total of 60 to 100 cm in thickness. The width of the openings is spanned by stone lintels or arches. The liwan is vaulted like the rest of the house. *(Ragette, 84).*

As a rule, orientation of the view of the house is down the valley; the side of the house carries several windows and offers both privacy and openness. The windows are usually high above ground and out of reach from the outside. One imported window is distinguished for its size and decoration and placed on the side of the view. Other windows are used for ventilation. The elevations are always designed from the inside and façades are usually symmetrical. Windows can be carried down to the floor to create a place for sitting called “mandalun” or may be placed close to the ceiling to give light and air. The main facade usually contains a great number of windows (=15) in different sizes and shapes.*(Ragette,150).*

Throughout the development of different house typologies, rectangular, gallery, and liwan, the rectangular window evolved mainly because of environmental considerations. Whereas the features that influenced the transformation of the rectangular window into the triple arched, in the central house typology, were mainly socio-cultural and economic.

The existence of the former three typologies was governed by criteria that nature imposed as well as the limitation of advanced technologies in the building industry; topography, solar exposure, humidity/precipitation and wind patterns all were taken into consideration. This was achieved through the many concepts of application; heavy masonry wall (thermal mass), solar exterior shading, ventilation, view, daylighting, etc.

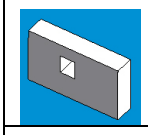
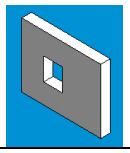
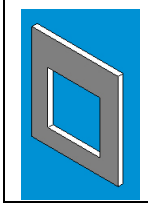
Window/Wall Typology + OUTCOME ○ NUTRAL ◘ - OUTCOME ●	SOLAR GAIN (HEAT) Summer Season	Winter Season	Mid Seasons	Ventilation	Daylighting	Social	View	Thermal Mass	Shading Fixed	Shading Vegetation	Infiltration	Materials	Orientation
	○	●	◘	◘	●	●	●	○	○	○	◘	○	○
	○	◘	◘	○	◘	◘	◘	◘	◘	○	◘	○	○
	●	○	◘	○	●	○	○	●	●	◘	○	●	◘

Table 2: Window/Wall Ratio - comparative analysis.

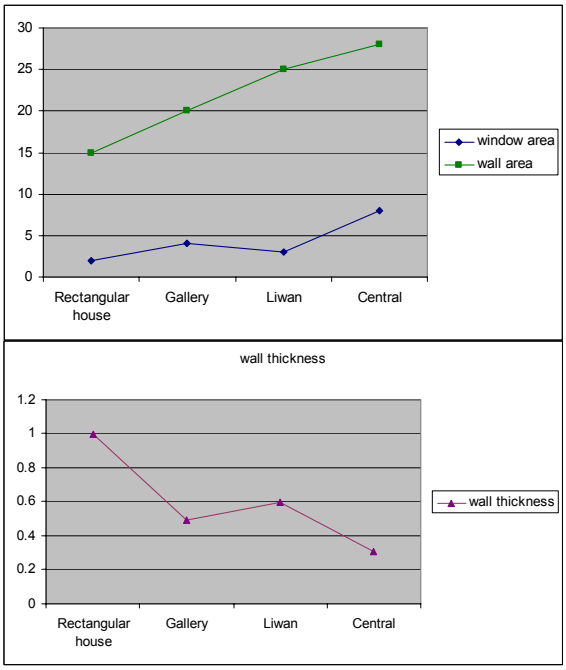


Table 3: Window/Wall - Typology Comparative

Thermal Mass
Lacking the view from the interior but maintaining the massive thick walls, the basic rectangular house obviously has an advantageous quality when it comes to thermal mass. In addition to maintaining a controlled interior comfort, the thick massive walls served as a shading device from high summer exposure; but even with limited size, the openings allowed the winter sun to enter. This was enhanced by the tapering of the wall towards the interior. This feature will gradually disappear with the evolution of the Lebanese house setting the view as the dictating criteria which is considered above all.

The co-relation between the thermal mass and the window openings was strongest within the rectangular house. With the reduction of the exterior wall thickness and the increase of the window size, the importance of maintaining comfort through constant levels of temperature slowly gave way to criteria of view, natural ventilation, solar gain and social activities. This was clear in the two typologies of the gallery and liwan houses. While in the central house, the thermal mass was no longer a priority.

Ventilation & Daylighting
With the development of typologies and the increase of interior space utilization for social activities, the demand for natural ventilation, in contrast to thermal mass, became an important strategy to integrate in the last three types of Lebanese houses to make-up for what was lost in terms of comfort due to the diminishing thermal mass. Larger windows imply greater solar gain and loss in contrast to better view and quality of natural daylighting. This became very obvious when float glass came into use at the end of the 19th Century. Auxiliary devices such as interior curtains and shading devices had to be used in situations of excessive daylighting and direct solar exposure during the summer season.
Prior to this date, wooden shutters were used and therefore maintained weak concepts of view, air infiltration and daylighting in the winter season.

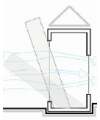
4.2 Small Openings

Figure 8: Small Openings

Throughout Lebanese vernacular architecture, small openings were used for purposes that enhanced environmental strategies of natural ventilation and daylighting. Their definitive placement was so critical in achieving the objectives especially during the winter season when the main rectangular window shutters were closed due to strong weather especially in mid-mountain, high-mountain and inland climatic regions. Seeing the depth of the thickness of the thermal-mass wall, one might wonder how light may enter the space. But with proper orientation, the rising or setting sun plays an effective role.

The dimensions varied between 10x10 cm and 30x50 cm and the openings were located either on the upper part of selected walls (above or next to the windows/doors), depending on orientation, and/or above the finished ground drawing in new fresh air when ventilation is needed for activities that involve cooking and heating within the space; an activity usually done outside in mid and summer seasons. When ventilation is not required, the lower openings are easily closed thus preventing the cross motion of air. The upper openings increased in number and in some case were found on different orientations for the purpose of daylighting, whereas ventilation openings were placed depending on prevailing winds. The use of these openings was evidently more flexible in the original rectangular house since the walls had similar thickness whereas the vaulted houses in all typologies restricted their use to the central part of the vaults. Within the gallery, liwan and central houses, these small openings developed to become an ornamented feature within the façade.

4.3 Triple Arched Window



With the turn of the 20th Century and the wide use of sheet glass, people began to feel the need for social expression through eclecticism and the influence they've experienced. Although the central hall type of houses appeared at a later stage than the ones described before, it's the true Lebanese house

Figure 9: Central Hall Typology (drawings by Ragette-19 Photos by *Liger-Belaire*).

which attains the highest degree of identity. Built on a slope, it consists of two floors with a single entrance to the main floor. Its symmetrical composition includes a triple arcade. The triple arch consists of three arches connecting above slender columns and either tie to a wall or are supported by half columns. In some cases, the number is extended to four or five arches. The total is a combination of a door which opens to a balcony or a rail-protected protrusion, and two windows forming a parapet. The arches were generally plane and open, until later periods when glass came in use. Wooden frames were fitted into the columns and arches with intricate designs and patterns of plane or colored glass. Every elevation has a balcony, thus a stronger relation with the surrounding. The new light-weight roof construction (reduction of the roof load) allowed thinner walls for the upper floors. The hall is well expressed from the façade (three arch motifs). *(Ragette, 154).*

Figure 10: Bay Window (*Liger-Belaire*).

The bay window, typical to Arab architecture (fig.10), was more common in Islamic communities and served as lookout for the harems. Resting upon stone corbels, the structure was mainly made of wood in a way to allow seeing without being seen. *(Ragette, 157).* Pateras, rosettes and circular openings display the same creative inventiveness and embellishments, also observed in keystones. A special feature is the high relief design cut hollow and pierced entirely out of one block, resembling medieval bosses. Sills vary in size (30-40cm up to 80-100), mainly due to the oriental habit of sitting on the floor. It later developed into what is called the mandalun combining a low window with a sitting platform. *(Ragette, 150,162).*

4.4 The Combination Window

The development of houses started with the simple rectangular house, gallery, to the liwan and central hall. The combination type developed from different features of the previously stated typologies simultaneously due to three different factors: economic considerations, local conditions and personal preferences. The famous palace of Beit-ed-Dine is a good example with an extensive complex of buildings, combining all the various types of design.

5. CONCLUSION

In recent days we can no longer formulate a pattern or set guidelines to window typologies in modern Lebanese construction. The leading factors controlling the window orientation, size and shape are governmental rules and regulations that are far from being environmentally conscious. The years of war brought more chaos and is best illustrated in “The Republic of Concrete” book, published by Dar An Nahar. Shy attempts are being done to correct the current situation by studies carried out by the UNDP and building legislation authorities.

Window design using modern sustainable technologies has brought flexibility to concepts of orientation, shape and size which makes it is easier to achieve required criteria.

What we build defines our identity and reflects our cultural behavior. A mere opening, that has changed throughout history on how we look from it or how we are looked upon. As F. Ragette wrote in his book on Lebanese architecture: “The houses of a people mirror the needs, desires and living habits of a time, because they are the direct result of the interaction between man and his environment.”

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