

# The use of the golden ratio in three traditional Lebanese architectural elements: Window, Mandalun and pointed arch.

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## Abstract

Traditional Lebanese architecture is one of the Mediterranean architectures that put emphasis on simplicity and harmony with its environment. However, few studies were devoted to describe in details this type of architecture. Even though, they classified the different typologies of houses and their architectonic functions, they mentioned the building techniques and construction, and they described briefly the materials used and the architectural ornaments. No one studied before in depth the geometrical proportions of these elements. In the present paper, the geometrical studies of three of the main repetitive architectural features of the traditional Lebanese architecture, window, Mandalun and pointed arch, are presented for the first time. A brief description of the element and of its origins precedes each one. Four types of windows, two Mandaluns, with and without planter, and a generic pointed arch were analyzed geometrically. This study showed that the golden ratio is well applied in each element, for aesthetical and stability motives.

*Keywords:* traditional Lebanese architecture, Golden ratio, Mandalun.

## Lebanese Traditional architecture

No doubt that Lebanon, one of those eastern Mediterranean countries, has a long history and embrace the first cities ever built (Beirut, Byblos, Tyr). It was a witness of the growing, fighting, passing, fading of many civilisations. It embodied the historical, cultural and religious influences of Phoenicians, Egyptian, Mesopotamians, Persians, Hellenics, Romans, Byzantines, Umayyads, Crusaders, Mamlucks, Ottomans and French. Not even though, its topographical characteristics (presence of deep valleys and high mountains which peak at 3088 m), geographical location and its moderate Mediterranean climate, made it an asylum for many religious groups escaping from intolerant environments: Christian Maronite (7<sup>th</sup> century), Druze (11<sup>th</sup> century), Arminian (19<sup>th</sup> century). Within this mixture and heritage of different cultures, religions, and after that Lebanon was convulsed by a series of outbreaks, including the massacre of 1860 [3], the three-arche

Lebanese house appeared [1]. This architecture is remarkable for its simplicity, mastery of craft, harmony with the surrounding landscape and prismatic clarity [1]. This period was characterized by the beginning of new era of economic prosperity in many cities and the development of a middle-class in the area favoured by Ottoman modernity and the rapid established relations with westerners [2] [3] [6] [8] [10]. The new middle class preferred to own this new typology of houses which were built all across the country presenting a great change in the previous traditional house [1] [2] [3]: the façade room or central hall opens onto the outside through an ornate triple arches, around the central hall many residence rooms were distributed symmetrically, often a balcony was there to prolong the main hall towards the street or the garden [6].



A) Three-arche Lebanese houses (19<sup>th</sup> and 20<sup>th</sup> c.) in: a) Douma, b) Baalbeck, c) Byblos, d) Beirut



B) Lebanese palaces in Esh Shouf (17<sup>th</sup>, 18<sup>th</sup> and 19<sup>th</sup> c.) of: a) Fakhr Eddin II, b) Yusef Shehab, c) Bashir II



C) Mamluk structures: a) Citadelle of Baalbeck (arches from 13<sup>th</sup> c), b) Khan Al Khayyat in Tripoli (12<sup>th</sup> or 14<sup>th</sup> c), c) Mosque Al 'Attar in Tripoli (14<sup>th</sup> c)

The presence of an open balcony within the Ottoman empire and in a society of Muslims and Christians was a rebellion design [10] which reflects the same liberal social conditions of life existed for both religious communities in Lebanon [1]...Lebanese people were open to new materials, thus, red roof tiles were imported from Marseilles in France, and they were mounted in a uniform slope on top of the three-arch house [1]. The recognition of those processes of change does not contradict the observation that the main elements of the Lebanese house (windows, doors, arches) did not change, though it adapted very well to urban change [2]. In this article, three elements of the traditional Lebanese house will be presented: window, Mandalun, and the pointed arch. Our studies show that old Lebanese builders used the golden ratio for the design of such architectural elements.

### Golden Ratio

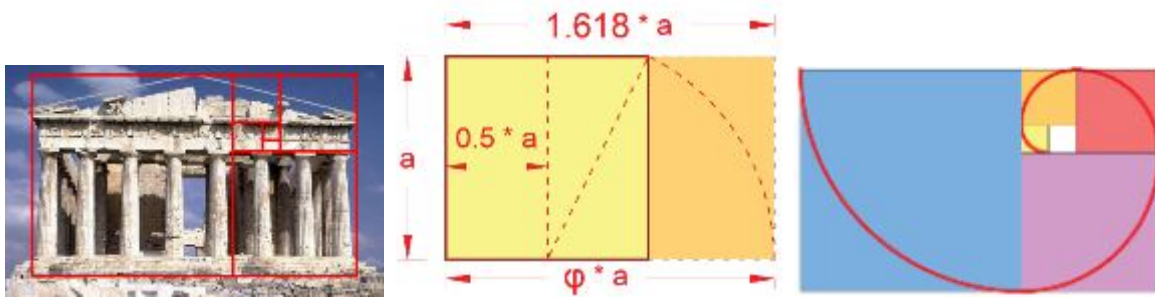
Based on Vitruvius' Book, three conditions define a good building: *firmitas, utilitas et venustas* [11]. In other words, the structure should be in the first place stable where stability is the most restrictive condition; it also has to assure the functionality of the space to suit the users' needs, and finally it should be beautiful. Proportion plays an important role in all three components. A structure is stable if its structural elements are stable; for this reason, they must have certain dimensions that depend fundamentally on the geometric shape of the structure. This leads to the existence of valid "proportions" for the design of arches, vaults, walls, and even buildings [4]. Moreover, the proportions of a space can dramatically change how visitors feel in it, and the proportions of a facade design can affect whether a building appears impressive, threatening or welcoming [11].

As a general rule, balanced buildings are more attractive to the eyes than other buildings. One of the simplest ways to impart a sense of balance to a structure is to base it off the principles of the golden ratio [11], [15].

The golden ratio, also known as divine proportion, is a geometric proportion that has been conceived to bring natural balance and visual harmony to any design.

It has long been believed to produce some of the most aesthetically pleasing shapes in nature, such as sea shells, arrangement of woody scales in a pinecone, and no surprise that architects also jump at the chance to build many architectural art pieces such as the Egyptian Pyramids, Greek temples, Alberti's Churches, Taj Mahal, Tour Eiffel... [15]

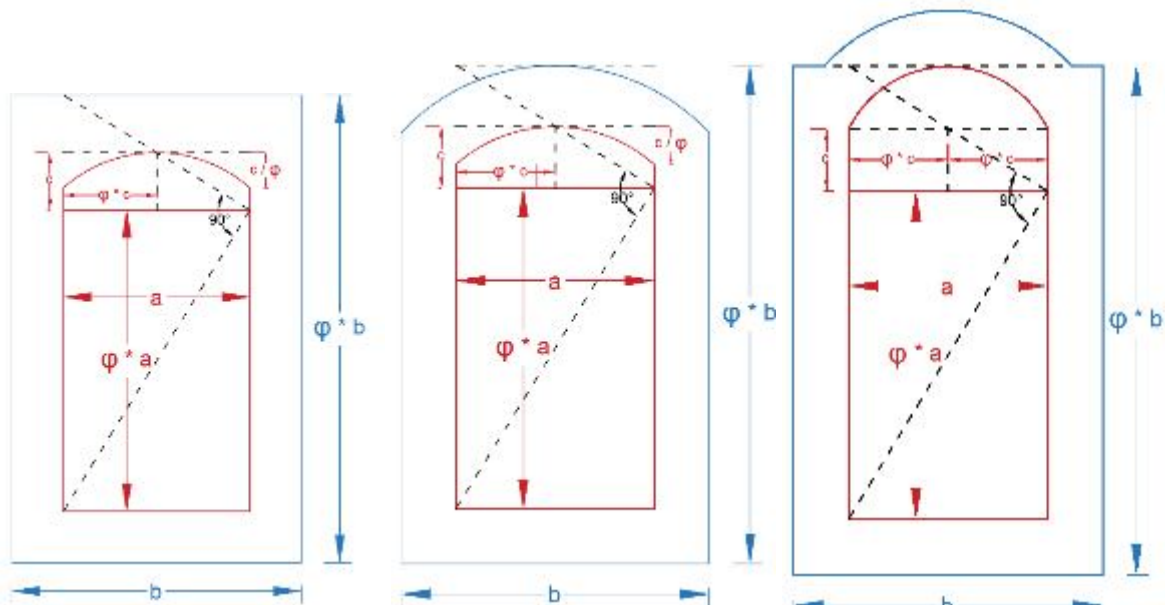
In brief, the Golden ratio is  $\phi=1.61803$ . A golden rectangle is a rectangle where the ratio of two adjacent sides is equal to the golden ratio. A golden triangle is an isosceles triangle in which the vertex angle is equal to  $36^\circ$ , or the ratio of the long side to the short one is  $\phi$ , in another words, it is the triangle found in the points of pentagrams, or in a regular decagon. Moreover, a Golden spiral is a logarithmic spiral with a growth factor equals to  $\phi$ .



D) Example of golden ratio and its application: a) Parthenon, Athen [15]; b) Golden Rectangle, c) Golden Spiral

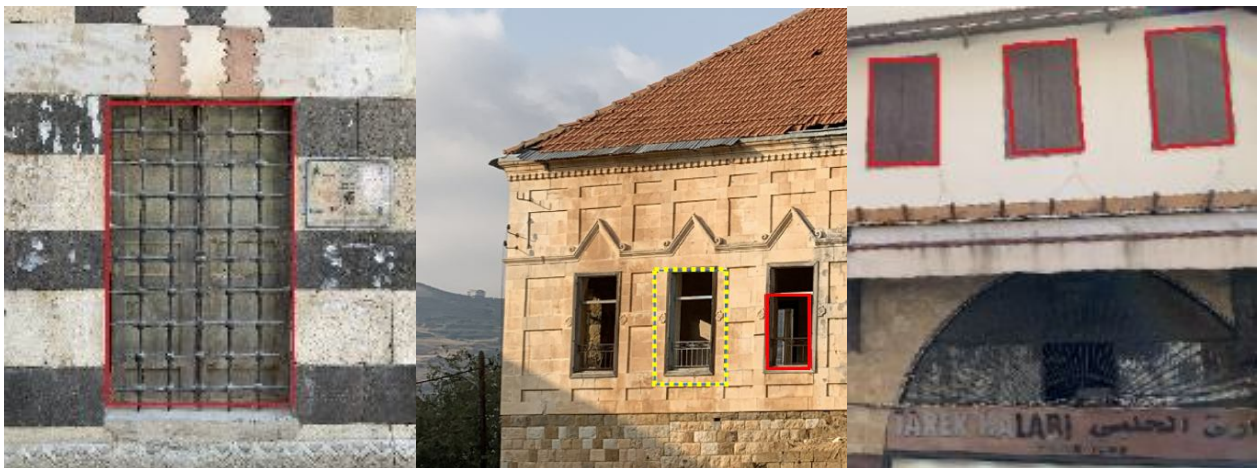
### The use of Golden ratio in Traditional Lebanese Windows:

The climate in Lebanon is a moderate Mediterranean climate with four different seasons. In the mountains, where most of Lebanese villages are located, the climate is especially cool and pleasant in the summer, cold and rainy with snow in the winter, with many streams of water, fresh air and open view to the sea [9]. This tolerance of climate gives the Lebanese people the opportunity to open big windows in their houses. Lebanese summer is unlike the intolerable summer heat in the plain and the warm, if not sweltering climate of almost all surrounding countries [13], were windows were resumed into small openings on the upper parts of the walls mainly for ventilation [12] [13]. It should be pointed out that in Lebanese traditional houses is possible to find different types of windows. Simple rectangular windows are well common in Lebanese houses since Mamluck time.



E) Traditional windows in Lebanese houses: a) rectangular lintel, b) & c) segmental arch lintel

Moreover, many windows with segmental arch were well spread in many constructions. In all cases, arches and window frames are kept plain and have a perfectly smooth finish [1]. Even the use of high small circular or square windows is common for ventilation, this study will refer only to the first two types. Golden ratio is applied well for traditional Lebanese windows. Along with the simple rectangular shape (figure F), it is possible to encounter more elaborated windows with segmental arch or in Lebanese dialect: Hlaliyyeh (from crescent), corniced by a rectangular (figure G) or segmental arch (figure H & I) lintels as it is remarkable in the figures below



F) Windows respecting the golden rectangle: a) 13<sup>th</sup> c. in Tripoli, b) 19<sup>th</sup> c. in Bazoun, c) 19<sup>th</sup> c. in Tripoli



G) Windows respecting design E-a: a) 18<sup>th</sup> c. in Beit Eddin palace, b) 19<sup>th</sup> c. & c) 17<sup>th</sup> c in Deir al Qamar



H) Windows respecting design E-b: a) 19<sup>th</sup> c. in Byblos, b) & c) 18<sup>th</sup> c. in Deir al Qamar



I) Windows respecting design E-c: a) 18<sup>th</sup> c. in Beit Eddin palace, b) & c) 17<sup>th</sup> c. in Deir al Qamar

### The use of Golden ratio in Mandalun

One feature that characterizes a big part of the Lebanese architecture is the presence of mullioned window or two-light window known as bifora. It is a coupled window with two horseshoe arches and a colonette in the middle [1]. With slight modifications, it is repeated countless times around the country [1]. Some houses present a grouping of three windows, in such case the word bifora is replaced by trifora. Mainly, the Lebanese bifora is framed by a segmental relieving arch that transmits the loads of the upper wall of the pointed arches to the adjacent walls; the space between the two arches and the segmental arch may be embellished with reliefs or ornamental cut-outs or a small circular opening [1].

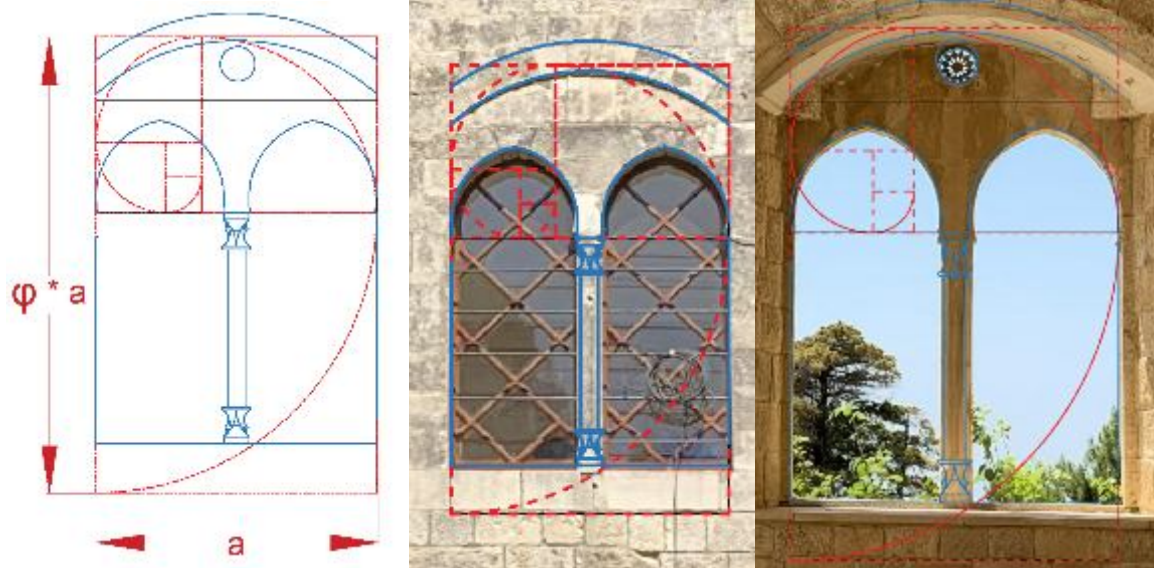
Biforas and triforas were known by the Byzantines. After that, Muslims in Spain used different shapes of biforas and low biforas as an essential element in their palaces. From here, the name of such architectural feature in Spanish is Ajimez, derived from the Arabic word *al-šamis* which means the place that enhances the presence of the sunlight. The main use of such Ajimez is to verse the outside from the inside without being seen. It has the same concept of Mashrabiya in oriental Islamic countries [13].

In Lebanon, a low bifora or low mullioned windows with a sill as low as 30 or 40 cm and a sitting platform is called Mandalun. The word Mandalun seems to be derived from the Italian word, Mandolin [1], a stringed musical instrument in the lute family which used to be played in that window space. It is remarkable the presence of mullioned window without any relieving arc in the third floor of one of the entrances of the palace of prince Fakhr Eddin II, dated back to the first decades of the 17<sup>th</sup> century. It may be recalled that prince Fakhr Eddin II acquired a taste for architecture during his stay at the court of Florence [9]. He had strong relations with the Grand Duke of Tuscany, Cosimo II De Medici, who send his engineers, Giovan-Batista Santi and Cesare Antogniacci to Lebanon in December 1613 to study the fortifications of the fortresses and seaports of the Lebanese prince [5]; after 18 years, in August 1631, upon a request from the same prince, Ferdinando II de Medici, son of Cosimo II, send to his friend other Tuscans architects and masons such as Francesco Cioli, Giulio Parigi and Francesco Cagni [5]... It is legal to ask why Lebanese people call such element Mandalun, an Italian derivative name and not *al- šamis*, the Arabic name?! This may reveal the influence and/ or the origin of the design and/ or the first designer.

Below some existent Mandaluns, it is possible to see the fourth dimension by the presence of a projecting planter [10]. The presence of planters reflects the Lebanese people's love for flowers [1] and the possibility of growing them due to the presence of enough water and moderate climate. The observations of some practitioners of conservation of traditional Lebanese houses lead to restrict the presence of the Mandaluns into gallery houses and court houses but never in three-arche houses with balcony [10].

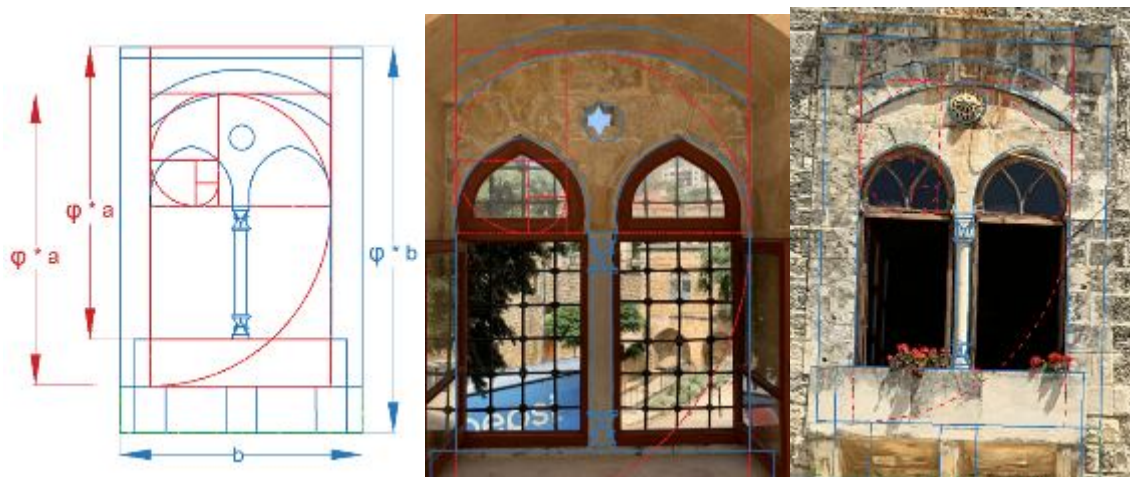


J) Mandaloun with planter: a) & b) 19<sup>th</sup> and 18<sup>th</sup> c. in Deir al Qamar, c) early 19<sup>th</sup> c in Beit Eddin



K) Mandaloun without planter: a) Design based on golden ratio, b) & c) outside and inside of a Mandalun 19<sup>th</sup> c in Beit Eddin Palace

However, nowadays the term Mandalun may be used to describe all type of biforas or gemelled windows used in Lebanon (normal biforas, low biforas with and without planter) [6].



L) Mandaloun with planter: a) Design based on golden ratio, b) & c) outside and inside of Mandalun 18<sup>th</sup> c in Dayr Al Qamar

The study referred to a Mandalun without planter and long colonette (figure K) and a Mandalun with planter and shorter colonette (Figure L). As it can be seen in the drawings above, the golden ratio is used in every part of the Mandalun.

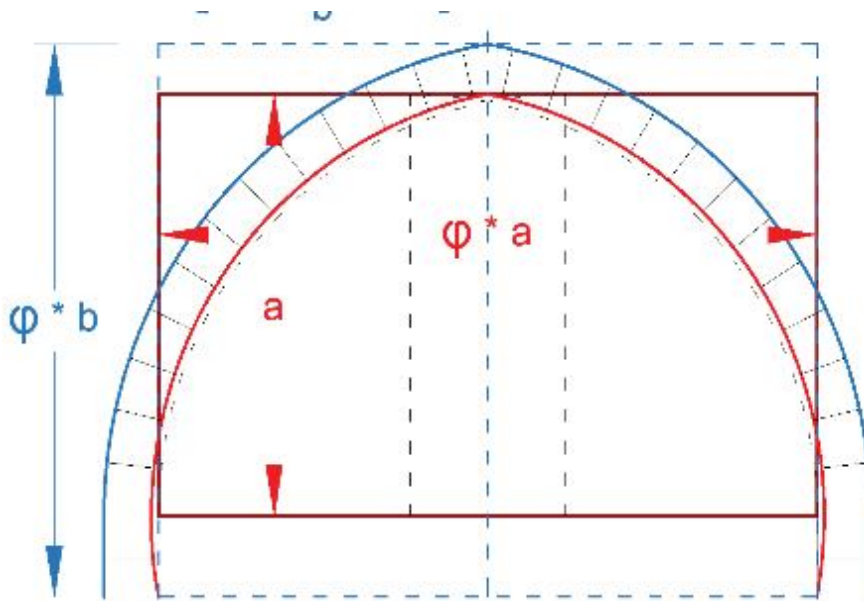


### The use of Golden ratio in Pointed Arch

The relation between Lebanese and arches started since the time of romans who introduced the semi-circular arches and vaults in all the roman empire. It is still possible to see until now such type of structures in roman fortresses as Baalbeck, and Ummayad palaces as the palace of Anjar (7<sup>th</sup> century). The introduction of the pointed arches or ogive arch took part after the Islamic period of the Abbasid Caliphate (9<sup>th</sup> century) and stole the lights from its predecessor the roman arc.

This way of construction made the arches light, of long duration and gave a facility in executing the vaults with little involved expenses [4]. Hence, the pointed arch is used for all types of constructions: housing, monuments and public buildings; and in many types of structural systems: simple pointed arch, pointed groin vault and pointed barrel vault [14]. These two later systems, in the traditional Lebanese architecture, are intended for basements, mezzanine and ground floor in commercial buildings and in old markets. This technique is sometimes used to build different floors in Lebanese constructions [14]. A pointed arch is used in Iwan houses, gallery houses and three-arche houses. The pointed vaults were used by all Lebanese and in all their constructions until the beginning of the 20<sup>th</sup> century. Old examples of pointed arches, pointed groin vaults and pointed barrel vaults are still existing in many Lebanese cities: a succession of pointed arches is used as a roof in the old city of Tripoli (Khan al Khayyatin, 12<sup>th</sup> or 14<sup>th</sup> century) [16], the palace and the south tower within the Citadel of Baalbeck (11<sup>th</sup> to 14<sup>th</sup> century) and no need to cite all historical buildings distributed around the country that used the pointed arches.

Figure M refers to a general pointed arch used in Lebanon, as a pointed arch or a section of a pointed vault. The dimensions of the arch verify the golden ratio.



M) The pointed arch and pointed horseshoe arch as built in major Lebanese historical buildings (from 12<sup>th</sup> until the beginning of 20<sup>th</sup> century)



N) Example of pointed arch in: 1) three-arch houses (19<sup>th</sup> c.) a) Bazoun, b) Baalbek, 2), c) Monastery of Saint Anthony kozhaia (19<sup>th</sup> C.)



O) Example of pointed arch in: 1) Mamluck Architecture (12 to 16<sup>th</sup> c.) a) Fortress in Baalbek, b) Market in Tripoli, 2), Crusaders Architecture (11 to 13<sup>th</sup> c.) c) Door in the city wall of Byblos, d) Market in Byblos



P) Example of pointed arch in: 1), a) Mamluck Mosque in Tripoli (early 14<sup>th</sup> c.), 2), b) Palace of Fakhr Eddin II in Deir Al Qamar (17<sup>th</sup> c.), d) Palace of Bachir II in Beit Eddin (18<sup>th</sup> c.).

## Conclusion

The present article listed three architectural elements from the traditional Lebanese architecture: windows, Mandalun and pointed arch.

The main objective of the article was to show that old Lebanese builders had knowledge of the golden ratio and they used it in all three elements. It is not clear if they used the golden ratio for only aesthetical features as in the case of the windows, or for sake of stability and convenience as in the case of the pointed arches. For lack of time, this article did not investigate from where Old Lebanese masons acquired this knowledge: from the foreign architects, engineers and masons brought to the country by Crusaders, Mamluck rulers, Ottoman Pashas and Lebanese prince, or it is rooted in the Lebanese builders and it was passed from generation to generation since old times?

It was cited that these elements were developed with interchangeable influences of climate, western and Islamic impacts, and the social conditions of the Lebanese people.

The moderate climate of Lebanon favored the execution of big windows and romantic mullioned windows, unlike other surrounding countries. The love of Lebanese for nature and the abundance of water then, made the possibility to put planters which is unusual in their Arabic and Islamic warm neighborhoods.

While Mandalun may have western origins, the design of pointed arch and what follows as pointed vaults were brought to the country by Islam, perhaps during Mamluck period (12<sup>th</sup> to early 16<sup>th</sup> century).

The liberal social conditions for both Christians and Islam, permitted the use of open balconies and Mandalun without any wooden screen or Mashrabiya (except of rare cases around the country) [13]. Future studies will be done on different classical elements from the traditional Lebanese architecture and further studies will cover small details and ornaments.

However, the verification of the golden ratio in traditional Lebanese structures does not give more credit to this architecture than other ones; that does not mean if a historical building where golden ratio is not applied, should be demolished. The main idea is to verify that this traditional architecture, which is part of the identity of the country, was based on well precise ratios and methodology; it should be conserved and well appreciated because a country without a proper identity, will be always imitating the identities of other countries.

## Bibliography

- 1) Friedrich Ragette, *Architecture in Lebanon, The Lebanese House During the 18<sup>th</sup> and 19<sup>th</sup> Centuries*, Caravan Books, 1980.
- 2) John Gulick, Conservatism and Change in a Lebanese Village, in *Middle East Journal*, Vol. 8, No. 3 (Summer, 1954), pp. 295-307.
- 3) John Gulick, *Tripoli, a modern Arab city*, Harvard University Press, Cambridge, Massachusetts, 1967.
- 4) Santiago Huerta Fernández, *Diseño estructural de arcos, bóvedas y cúpulas en España ca. 1500~ca.1800*, Escuela Técnica Superior de Arquitectura de Madrid, Madrid, Octubre de 1990.
- 5) Mariti Giovanni, *Istoria di Faccardino: grand-emir dei Drusi*, Livorno 1787.

- 6) Traditional Mediterranean Architecture, houses with three arches, Lebanon, Corpus, EUROMED heritage, Nov 19, 2003
- 7) Traditional Mediterranean Architecture, Lebanese house, Syria, Corpus, EUROMED heritage, May 13, 2004
- 8) Maurice Cerasi, *The Formation of Ottoman House Types: A Comparative Study in Interaction with Neighboring Cultures*, Muqarnas, Brill, Vol. 15 (1998), pp. 116-156.
- 9) Richard Pococke, *A description of the East and some other countries*, Vol II. Part I, in “Observations on Palastine or the holy land, Syria, Mesopotamia, Cyprus, and Candia”, London, 1745
- 10) Antoine Lahoud, *Interview with Al Mayadeen*, Aug 11 2018
- 11) Inge Beckel, Richard Toovey, *What Makes a Good Building*, World-Architects, Jan 13 2014
- 12) Olimpia Niglio, *Akko (Israele), Città del Mediterraneo*, I), 2007. Available at: <http://www.webjournal.unior.it/Dati/19/71/Web%20Journal%203,%20Akko.pdf>; Olimpia Niglio, Akko, the pearl of the Mediterranean. *Apuntes* [online]. 2009, vol.22, n.2, pp.116-123.
- 13) Ayman Fathy Ashour, *Islamic architectural heritage: Mashrabiya*, University of Sharjah, United Arab Emirates, WIT Transactions on The Built Environment, Vol 177, WIT Press, 2018
- 14) Architecture Traditionelle Méditerranéenne, C6, Voûte en berceau, Syrie, Corpus, EUROMED heritage, 2003-2004
- 15) Gyan Bahadur Thapa, Rena Thapa, *The relation of Golden Ratio, Mathematics and Aesthetics*, Journal of the Institute of Engineering, 2018, 14 (1), pp. 188-199.
- 16) Roula Hmaid, Khan Al-Khayyateen, Alkhaleej, Beirut, January 30 2014.