Journal of Civil Engineering and Architecture 12 (2018) 816-829
doi: 10.17265/1934-7359/2018.11.005

Characteristics of the Architectural Structures Belonging to the Transition Period in Beirut (1840-1920)

Youssef Hamze and Jad Hammoud

1. Faculty of Engineering, Lebanese University, Hadath Campus, Beirut 961, Lebanon

2. Faculty of Fine arts and Architecture, Lebanese University, Hadath Campus, Beirut 961, Lebanon

Abstract: Conserving the architectural structures of heritage buildings has become an important issue in Beirut. It is the result of necessary retrofit of existing traditional bourgeoisie architecture of 19th century, belonging to the late Ottoman period, recognizing the importance of its traditional technics and to keep them in use. Although, they have been subjected to lack of maintenance and repair which led to processes of severe degradation, compromising their use, it allows now a deep observation of their characteristics. The main goal of this article is: to outline the evolution of the construction of this late Ottoman Heritage; characterize its architectural typology; understand the impact of Building Codes; and present results of surveys. For the analysis, non-destructive methods were performed. The survey of three case studies according to a pre-selection of representative Ottoman buildings (1840-1940) is presented. This intends to contribute for the conservation of Beirut traditional housing and give useful technical information.

Key words: Word, structural evolution, construction technics, building construction, conservation historic buildings.

1. Introduction

Heritage buildings are defined as existing buildings with significant cultural value to society. These values are reflected from the characterization of the architectural building construction in this case, belonging to the late Ottoman period. Building construction is the subject that possesses the widest interest among practical architects and engineers, because it teaches them not only how to read things but how things work [1]. So, the more they learn about it, the more they want to know. The history of buildings is marked by several of changes, one is the increasing use of the industrial materials. Early building materials were timber, rubble stones, and clay. Later, more durable natural materials as limestone, ashlar were used and in addition with industrial materials, such as brick, concrete, iron and steel. Understanding the construction system is the base of the evaluation process to conserve or retrofit when needed. To focus on the knowledge of the construction specifically, having national regulations and standards, is the base to know the vertical and horizontal growth of the built environment in Beirut. The methods and processes of construction were developed about the materials available locally and the skills of the craftsmen acquiring a richness over time. Understanding an overview of the history can draw the development of characteristics that led to the acknowledgement of Built heritage. Before 1840, Beirut was inside its walls, it was formed by gathered and adjacent houses in a narrow land with 750 m long and 370 m width, surrounded from its four sides by defence walls. The land use outside the walls was agriculture. It was largely a mixture of mulberry plantation trees and an agricultural land use, which had good influence in the production of silk that began in the 17th century in these garden fields [2]. Few huts were erected within the plantations that were probably built for the cultivation of silk. Beyond that, in the early 19th century, huts and small buildings of stone and wood are used as storages, workshops, and small permanent residence houses. Many works, researches by Kalayan [3], Ragette [4], Davie [5] and Abousouan were done

Corresponding author: Youssef Hamze, Ph.D., associate professor; research filed: civil engineering.

about the traditional domestic architecture in old Beirut identifying several housing typologies, starting from the peasant or farmer house to the *Iwan* house (Table 1).

Growth of Beirut was developed in 19th century when some wealthy Beiruti families escape from the old city during the hot weather to enjoy greenery, a panoramic view and the fresh air provided by the prevailing south-western summer breeze. Defensive walls were then demolished, and new construction was permitted to form the Beiruti house with its new architectural typology in 1860s, the heritage of 19th century. The destruction of Lebanon's fifteen years of civil war between 1975 and 1990 affected the city's architectural heritage. But in the end, after all the bombs, it was politics that destroyed this city, not tanks during the war, it was bulldozers and politicians as Giorgio Tarraf says, the spokesperson of Save Beirut Heritage. The idea that for new projects to go up, something must be torn down, often means the city's old buildings destruction. Of a list of 1,000 traditional buildings compiled by the Lebanese government in the 1990s, fewer than 300 remain. Many more buildings are architecturally significant yet are afforded no level of protection in the government's strategies. The analysis of urban functions, uses and building conditions has received much, and increasing, attention in the last 30 years. Based on the survey done by APSAD (Association pour la Protection des Sites et Anciennes Demeures au Liban) in 1996 for the historic buildings built during late Ottoman period and French Mandate period, 15% of these buildings are in very bad condition, 65% are in bad condition, and 20% are in good condition. Originally private residences surrounded by spacious gardens are nowadays attached to a dense ensemble of high-rise concrete blocks hiding the rich and unique architectural style for the historic residential buildings. Many cracks appear on the walls threatening the building to collapse. Today the ground floors of those residential buildings are used as shops, workshops and garages while some of the upper floors are inhabited (Table 2).

A main purpose, to continue in the proposed future research, since there is a huge need of scientific knowledge and conservation guidelines in Beirut, which can support an adequate long-term protection and a management system, for this specific heritage, taking in consideration the standards of authenticity and integrity proposed by UNESCO. In this sense, the evolution of the architectural heritage of Beirut belonging to the transition period, from the Ottoman

Table 1 The five main typologies of the Lebanese traditional architecture [6].

Typologies adapted by the Directorate General of Antiquities 2005 (Corpus)	Davie May 2004	Abousouan 1986	Ragette 1974	Kalayan 1970
Basic single unit house	The *Koukh*	Rectangular plan house	Rectangular plan house	Rectangular plan
Multiple unit house with more than one floor	The *Sakan* or the *Bayt*			
Court house	The *Dar*	*Khan* type	Court house	Atrium plan
Riwaq house	-	Gallery house	Gallery house	Exterior gallery plan
Iwan house	Iwan house	Liwan house	Liwan house	Liwan plan

Table 2 Condition and ground floor use of historic buildings in Beirut 2003 [7].

	Residential	Retail	Institutional	Workshop	Abandoned	Sum	% of total
Excellent condition	9	2	13	0	0	24	10%
Good condition	7	6	9	1	2	25	11%
Medium condition	67	18	2	7	8	102	44%
Bad condition	40	4	0	2	1	47	20%
Very bad condition	12	3	1	3	16	35	15%
Sum	135	33	25	13	27	233	100%
% of total	57%	14%	11%	6%	12%	100%	

period 1840-1920 until the French mandate 1920-1940, is presented in the following chapters.

2. Characterization of Ottoman Beirut Buildings Architectural Typology and Construction System

2.1 Brief Description of the Case Studies

This research selected three buildings, representative of the Ottoman residential buildings in Beirut which represents the specific characteristics of the Bourgeoisie architecture in Beirut. This is important information since there are not almost any detailed research studies on the construction techniques of these buildings, dating to the late Ottoman Period. The three buildings are identified as: Bchara el-Khoury Mansion, Kaaki house, Ashrafiyyeh house.

2.2 Case Study 1 (Bchara el-Khoury Mansion)

The mansion is located between two street junks that flank the plot in Zokak el-Blat region. The major one Rue Osman Bin Affan on the east-west and the other is Rue Patrakiyeh and its extension to the North. It is one of those stately mansions which were built during the later 19th century on the hill-slopes outside the old city of Beirut, and which, with their colorful facades and their red-tiled hip roofs. The house is Bchara el-Khoury mansion, named as its longtime owner family. It is currently used as workshop for carpenters at the ground floor while the second floor is abandoned. Seen from outside Bchara el-Khoury mansion is a quite imposing load-bearing structure. The plaster which must have been ochre color in early days is now weathered and bullet pocked. In many windows are missing their glazing. The building is surrounded by an elevated open gallery at the two floors with pointed arches on marble columns. The mansion has a red tiled hip-roof. The mansion is built by plastered sandstone masonry and is consisting of two floors, a ground and first floor with space around 600 m^2 each, making it one of the biggest surviving mansions in Beirut. Typologically, this mansion can be classed with the type of late 19th century Beiruti upper bourgeois mansions. At the ground floor, the ceiling is almost five meters high and has iron girders with stone fills in between. The floors of the rooms are tiled with colored cement tiles with geometric pattern, framed by a line of cement tiles with floral pattern. The ceilings are carried by long iron girder with I-shape supported at the stone walls. The spaces above the girders are screened with substrates. Between the iron girders run vaulted stones. At the western end is the vaulted kitchen and two small inbuilt rooms with the toilets. Several double wing doors in

Fig. 1 Location of the three surveyed buildings in Beirut [8].

Fig. 2 Main elevation (Hammoud J. 2016).

Fig. 3 Triple arcades at the central hall.

Fig. 4 Jach arch slab at the ground floor.

Fig. 5 Span queen post roof truss (idem).

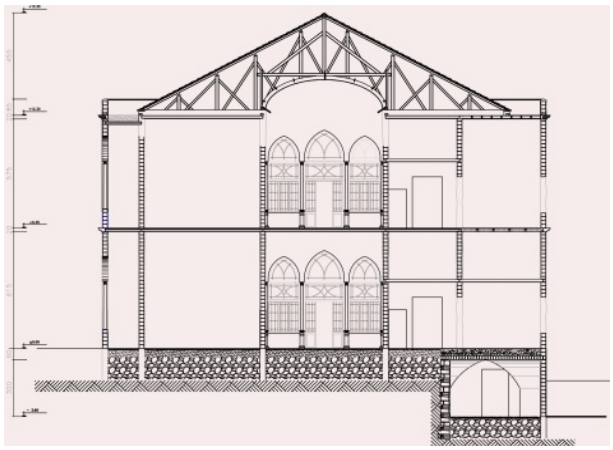

Fig. 6 Section (idem).

Fig. 7 Ground and first floor plans (idem).

the central hall open to the rooms and to the staircase that leads to the first floor. The first floor is in bad condition due to water infiltration from the damaged hipped roof which is carried on wooden beams that are closed by wooden fillings from below.

2.3 Case Study 2 (Kaaki House)

The house is located between two street junks, the major one Rue Osman Bin Affan on the east-west and the other is Rue Khalil Sarkis and its extension to the North. It is one of those stately houses which were built during the 1870's on the hill-slopes outside the old city of Beirut, and which, with their colourful facades and their red-tiled hip roofs. The house is abandoned and much damaged. The house is built in plastered sandstone masonry and is consisting of two floors, a ground, first and a red tiled hip-roof with space around 285 m^2 each. Typologically, this house can be classed with the type of late 19th century Beirut middle bourgeois mansions. The house is set back from the two streets in the midst of a vast garden. The main façade of the house, the northern façade, looks onto the garden and is divided into three parts: in the centre there is a peculiar window consisting of three horseshoe arches carried by twin columns of marble. The window has the most glazing and the woodwork with elaborating iron bars. The southern façade is divided into three segments: in the centre is a slightly protruding bay having classical rectangular windows as described above. The left and the right segments of the façade are symmetrical having the classical rectangular windows with wooden shutters from outside. The façade is covered by red-tiled hipped roof while the part having the kitchen and toilets are flat roof. The entrance of the house is from the north through the side entrance called vestibule, a dark room, which leads to the central hall through double wooden swing door. The floor of the central hall has white marble tiled with the black grid. The ceiling is almost 4.5 meters high and has main wooden girders. Above it runs the cross beams carrying wooden fillings painted with green. The parameter of the ceiling is lime plastered and painted stucco in cream colour. Several double wing doors in the central hall open to the rooms and to the staircase that leads to the first floor. The floors of the rooms are tiled with coloured cement tiles with geometric pattern, framed by a line of cement tiles with floral pattern. The ceilings are carried by long wooden beams at the stone walls. The spaces above the beams are screened with substrates. Triple arcades separate the central hall to the Iwan. Its triple arch on fluted square marble pillars is on one axis with and

corresponding to the triple arch of the central hall. At the north-west end is the vaulted kitchen and two small inbuilt rooms with the toilets and mezzanine floor. An outer stone staircase leads to the first floor which has the same description as below except the kitchen that is built with brick walls and a lime concrete ceiling.

2.4 Case Study 3 (Ashrafiyyeh House)

The house is located along Salim Bustros street in Ashrafiyye region prolonged to the North. It is one of those stately mansions which were built during the 1870s on the hill-slopes outside the old city of Beirut. The house is built in plastered sandstone masonry and is consisting of three floors, a ground, first, and second floor with a red tiled hip-roof with space around 185 m^2 each. Typologically, this house can be classed with the type of late 19th century Beiruti middle bourgeois mansions. The ground floor was vaulted and was used as shops. It is closed now having no access to it. The main façade of the house, the northern façade, looks onto the street and is divided into three parts: in the center there is a peculiar window consisting of three horseshoe arches carried by twin columns of marble and a marbled balcony is protruded to the street. The window has the most glazing and the woodwork with elaborating iron bars. The left and the right parts of the façade are symmetrical having the classical rectangular windows with wooden lamella shutters and moulded stone lintels covered with plaster rendering from outside. The entrance of the house from the west through the side entrance called vestibule having a *baghdadi* wall (wooden construction system) to the right, which leads to the central hall through double wooden swing door. The ceiling is almost 4.5 meters high and has main iron girders. Above it runs the cross beams carrying wooden fillings painted with green. Double wing doors in the central hall open to the rooms and to the staircase that leads to the second floor. Its ceilings are carried by long wooden beams at the stone walls. Triple arcades separate the central hall to the exterior. Its triple arch on fluted square marble pillars is on one axis with and corresponding to the triple arch of the central hall. At the south-west end is the kitchen and two small inbuilt rooms with the toilets and mezzanine floor.

Fig. 8 Timber cut beam in the central hall with adorned ceiling (idem).

Fig. 9 East elevation.

Fig. 10 Top view.

Fig. 11 West elevation (idem).

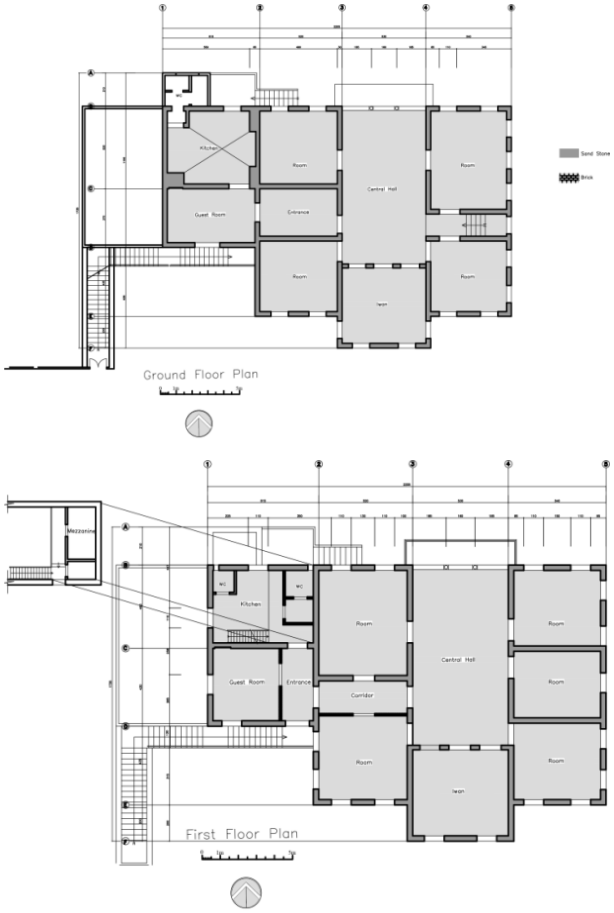

Fig. 12 Ground and first plan (idem).

Fig. 13 Top view.

Fig. 14 East elevation (idem).

Fig. 15 Timber cut beam in the central hall at first floor (idem).

3. Construction Technique of the Structural System in the Case Studies

The results of surveys undertaken to the buildings belonging to the transition period were divided according to the construction components of the building: foundations, slabs, walls and structure of the roof. These buildings were built using the stone as the principal material for load-bearing walls. Stone masonry is a traditional form of construction that has been practiced for centuries in Beirut where stone is locally available. Stone masonry has been used for the construction of some of the most important structures in this region. Buildings of this type range from cultural and historical landmarks, often built by highly skilled stonemasons.

Fig. 16 Ground and first floor plans (idem).

3.1 Foundations

The foundation is the lowest part of the structure of a building, built partly or wholly below the surface of the ground. Its primary function is to support the superstructure above and transmit its loads safely into the earth. In the studied buildings, it was difficult to observe the foundation of the three of them. Excavation done from outside and from inside for the Kaaki house only, shows that the exterior stone walls laid on the foundation while the interior walls laid on compacted soil. The footings are made by stone masonry, it begins with implementing large stones to be laid as a base for the wall. When the soil was back filled, the top of these foundation stones was left exposed in order to minimize the amount of water that could rise into the body of the wall above (Fig. 17).

3.2 Slabs/Floors

Type 1: Arched vaulted (ending in the second half of the nineteenth century)

The ground floor of some central hall houses in Beirut was arched vaulted. The vaulting cannot be built of uncut stones. The kind of vaulting is like the half spherical dome which requires rotational symmetry depending on whether it is a real or blind arcade. The vaulting starts from the plane of the upper part of the windows. This is the level of the second stage of the scaffolding. The possible techniques of building need to be weighed up, considered very carefully. For functional reasons the support for the forces in the knee walls, stability of the vaulting, has roles in the building process as well. As shown below, scaffolding is erected inside the building, but the vaulting can only be built from the top of the load-bearing wall. At the same time the half wall provides a helpful position for the masonry work for the vaulting. As the first step, the half walls are built up to the possible height. Following this, it is moulded and built the lower part of the rotational symmetric vaulting. The wall filling is required for the continuation of the building process, because it serves as the support for the half way scaffolding. From the wall filling we finish the knee wall, and from this we finish the vaulting. We must not forget that the building of the vaulting is happening in greater height (Fig. 18).

Type 2: Intermediate slabs: (1840-1900s)

In regard to intermediate floors built in Beirut, it was found two kind of roof constructed between one generation and another. At the beginning of the nineteenth century, the intermediate floors consisted of a timber frame with machine-cut beams carried on a large spanned timber beams linked to the walls. Tiling is applied at the top of this surface by adding a layer of aggregates with lime screed below the marble tiling (Fig. 19). This is present in Kaaki house. This kind of ceilings ended by 1880s, where the I-beam slabs were replaced instead of large spanned timber beams lifting small timber beams & joists (Fig. 20).

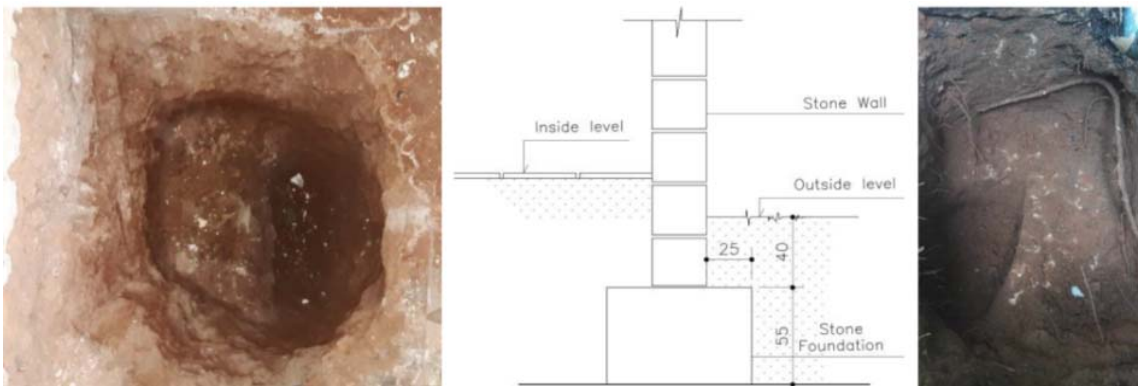

Fig. 17 Exterior walls (kaaki house) are constructed on a stone foundation as shown (idem).

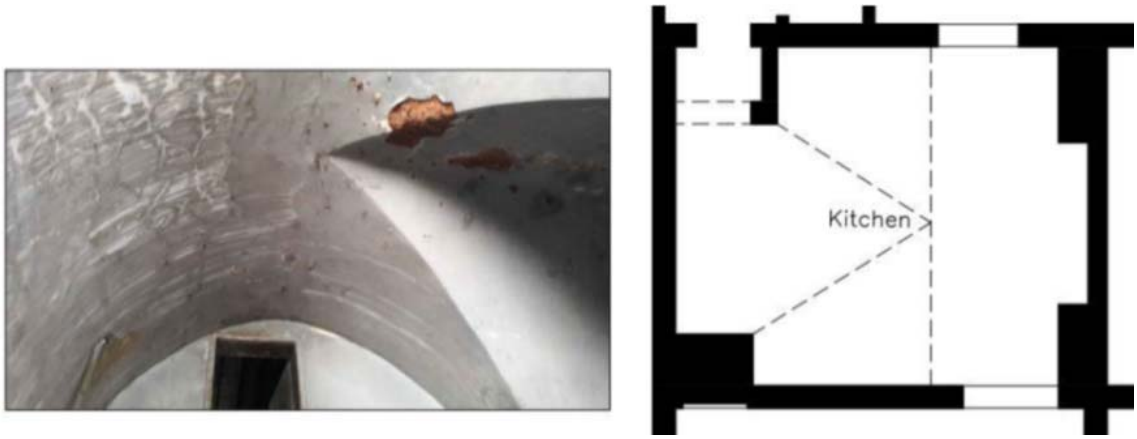

Fig. 18 The arched vaulted floor in kaaki house (idem).

Fig. 19 Construction of intermediate ceiling in kaaki house before 1880s (idem).

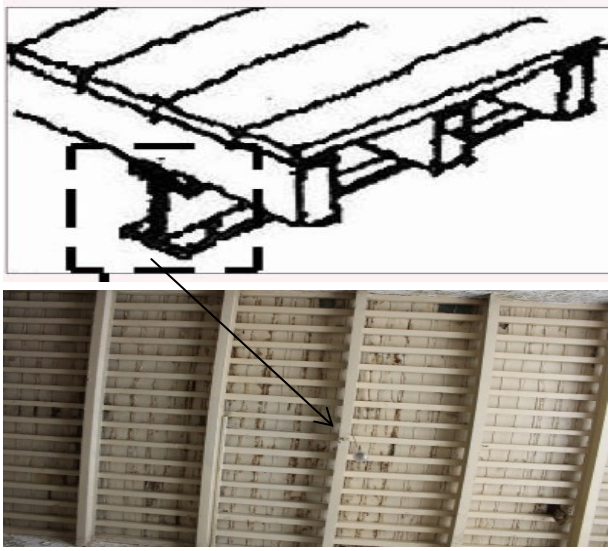

Fig. 20 The construction of intermediate ceiling after1880s when I-beam started to appear (idem).

In the late Ottoman period, neo-traditional buildings, cement tiles appeared in non-reception areas next to the central hall. Tiles were made from clay (often locally sourced), or poured lime cement always having a square edge. This square edge is significant and is the key to the flat surface that these floors have, unlike some modern reproductions. A layer of course, cheap clay about 10 mm thick was installed between two layers of clay, each about 3 mm thick, the top layer containing the imprinted as they became known, design. Imprinted pattern making remained essentially a hand-crafted operation, patterns were impressed into the wet clay with the use of machine presses, but pouring the colour “slip” (slip is the term given to wet clay mixed to the consistency of cream) into the impressions was a hand skilled job, which after two or three days drying, would be scraped flat by hand, revealing the pattern with sharp clear edges. The tile was then left to continue to dry slowly, as speeding up the drying time too much could also result in warping. Drying time for plastic clay was up to three weeks before firing, resulting in a slow production time (Fig. 21).

Type 3: Jack arch slab: (transitional period after 1890)

In the last part of the nineteenth century, new construction techniques for slabs were used to replace the intermediate floors type [9]. First I-beams were added to reinforce the timber floors. After 1890, and specifically in Bchara el-Khoury mansion, new armed

technique using iron rods and bricks, made spaces possible to achieve wider spans, to build higher, and develop ground plans more flexible than ever before. Jack arch slabs were created on site with a limited use of pre-cast elements comprised of cast iron girders embedded within insulation materials that spanned between them in the form of arches. In Bchara el-khoury mansion the insulation material used was stone. So, intermediate slabs (wooden slabs) were replaced by the tack arch slab announcing the second generation of post-industrial buildings and the start of the scientific phase [9]. A composition of cement with gypsum was being used in decoration that covers the structure of the slab as shown in Fig. 22.

3.3 Walls

Most of the exterior and interior walls are built with the bonding technique of lime and sandstone where mortar as binding material technique. The structure of stone masonry is defined by quality of the preparation of the materials implemented raw squared stones, mortar more or less abundant and consistent and following the design of the wall, which shows to be homogeneous in the studied cases. The size, shape and organization stones in the wall determine from its volume which will be filled by mortars. The traditional lime mortars being more permeable and less resistant than stone wall. We can classify the walls techniques in Beirut into four types [10] and this is according to three case studies only:

Type 1: Dressed quarry stone wall: Construction work using regular shaped cut stones is characterized by the interchange ability of the stones and the use of stones specifically cut to size and hewn to fit the place. It is rough sandstone, its length is between 30 and 40 cm, course height between 20 and 30 cm and depth is 20 cm for the single facing wall is generally left bare and are pointed from outside washed with lime plaster. This kind of stone has good benefits on the scaffolding. There is no need for large number of stones to be stored on the scaffolding. As a result the scaffolding can be simpler and lighter, because they are not loaded by the great weight of the stones. The supporting beams were blocked in to the rising wall. The walkways were positioned on the horizontal beams fixing out from the wall. The master builder was assisted by helpers. The building material is carried up by the unskilled workforce on ramps or ladders, or lift up by pulleys fixed to the higher beams. The heavier stones were hoisted up using a winch, supported by a tripod. The stonemasons work at ground level, where others mixing the mortar. The details of the wall construction can be seen in Fig. 23.

Fig. 21 Poured lime cement tile used in late Ottoman period in Bchara el-Khoury mansion (idem).

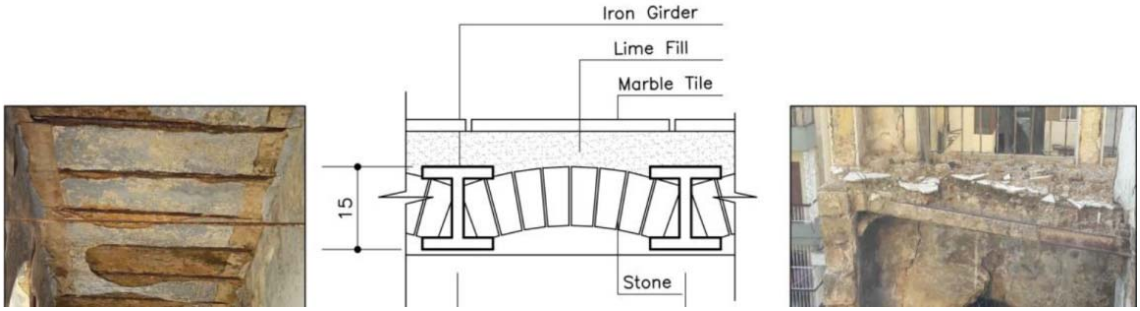

Fig. 22 Notifying the development of armed technique using iron rods and stones, where spaces are possible to achieve spans wider. The photo shows in details the existence of Jack arch slab in Bechara el-Khoury mansion (idem).

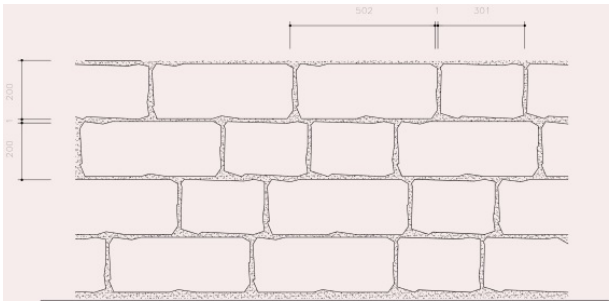

Fig. 23 Dressed quarry stone wall in Kaaki building (idem).

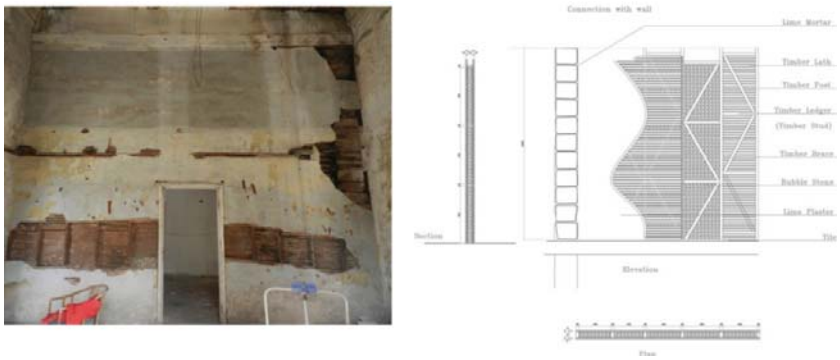

Fig. 24 Baghdadi construction (idem).

Fig. 25 Showing the brick construction in kitchen and toilet area in Kaaki building (idem).

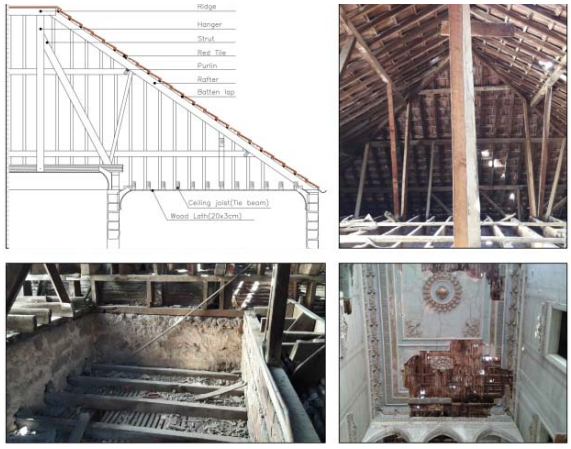

Fig. 26 Showing the construction of Hipped Roof used in Kaaki building (idem).

Type 2: Wooden frame wall (Composite Construction): This construction is a composite application of timber frame and massive stone techniques. It is a partition between one space and another in the house and not considered as bearing wall.

The filling of timber frame is local rubble limestone, earth and lime mortar. The total thickness of the wall is 15 cm whereas the outer surfaces were either plastered or non-plastered or wooden plastered. This wooden structure consists of wooden sections (10 × 8 cm) and wooden laths (2 × 1.5 cm) which is called *bagdadi* construction (lath technique) (Fig. 24).

Type 3: Brick masonry is construction in which uniform units (bricks), small to be placed with one hand, are laid in courses with mortar joints to form walls. Bricks are kiln baked from various clay and mixtures. The chemical and physical characteristics of the materials vary considerably. These characteristics and the kiln temperatures combine to produce brick in a variety of colours and harnesses. In brickwork, those bricks laid lengthwise in the wall are called stretchers and the course in which they occur, a stretching course. Bricks laid across the wall thickness are called headers and the course in which they occur, a heading course.

3.4 Roof Timber Hipped Red Tile Roof (Second Half of the Nineteenth Century)

The adoption of the pitched red tile roof with a timber frame structure was a major innovation compared to the massive preindustrial flat roof. This new structure reduced and relieved the vertical loads on external walls since the weight of the wooden structure is smaller, but on the other hand if the covering structure is not well idealized the action transmitted by the roof, in the walls can be more burdensome due to the horizontal component. To avoid this, common rafters were fixed at the ridge and at the wall plate. When subjected to any type of load or force acting vertically downwards the rafters will move outwards at their feet thus exerting thrust to the walls forcing them outwards and causing possible failure of the wall structure. To stop the roof joist from bent, a hanger is fixed to the rafter at the top and the ceiling joist at the bottom. To increase the strength of this structure, a binder is fixed to each ceiling joist and hanger. This binder runs parallel with the main wall and at right angles to the ceiling joist. This type of structure ensures that this type of roof can be used for great spans without the fear of the roof spreading under loads.

4. Conclusions and Final Remarks

The late Ottoman buildings in Beirut offer a unique case-study into the makings of a building type as a response to the needs of the context. The structural strategy has evolved as a direct response to available material technologies, functional needs and guidelines from the Building codes. This is evident in the way each primary material manifests itself in the building. The spatial planning of the house is a direct resultant of the structural system and together they form an architecture which is cohesive providing an understanding of the systems used in their making which represent the richness of Beirut heritage. The results of this research can aid future conservation efforts, as well as to encourage the conservation of these buildings which form an important link in the historic evolution of structure and the architecture of the region in its time-period.

References

[1] Adams, H. 1906. *Adams Building Construction*. New York: Routledge.

[2] Du Mesnil Du Buisson, R. 1921. *Les anciennes défenses de Beyrouth*. Syria: Paul Gueuthner.

[3] Kalayan, H., and Liger Bellair, J. 1966. *L'habitation au Liban, Beyrouth.* Beirut: APSAD.

[4] Ragette, F. 1974. *Architecture in Lebanon. The Lebanese House during the 18th and 19th Centuries.* Beirut: American University of Beirut.

[5] Davie, M. 1996. *Beyrouth et ses Faubourgs (1840-1940).* Beirut: IFPO.

[6] Fischfisch, A. 2011. *Formes Urbaines et Architecturales de Beyrouth (Depuis le XIXe Siècle jusqu'à nos jours).* Beirut: ALBA.

[7] Kogler, O. 1997. “Walking through Zokak el-Blat: A Rhythmanalysis of the Quarter.” In *History, Space and Social Conflict in Beirut*. Beirut: OIB.

[8] DGU, Directorate General of Urban Planning, Lebanon. 2011.

[9] Saliba, R. 1998. *Domestic Architecture between Tradition and Modernity*. Beirut: OEA.

[10] CORPUS, L. 2004. *Architecture Traditionnelle Libanaise, Ministère de la Culture*. Liban: Direction Générale des Antiquités.