

The Architecture of Connections in Mamluk Architecture
“The Methodology of Design by Connection Elements in Complex Buildings in Mamluk Eras Case-Study”

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Abstract:

The architecture of connections characterizes the spatial system in terms of how its spaces are related to one another rather than how it is geometrically composed. The variations of connection elements had founded in the architecture of Madrasa buildings, suggested that the underlying design principles or these unwritten design methods of Mamluk architecture exists at the level of the physical form, and because learning from the built environment of Mamluks is a legitimate approach to improve the modern theories and criteria of design, the research aims to “Discovering the Methodology of Design by Connection Elements in Complex Buildings in Mamluk eras”, to achieve this objective the research shade light on the design criteria, the types of connection elements and design techniques in the architecture of connections in Mamluk architecture,. The research suggested a generative technique for the design of Madrasa buildings by the aide of connection elements, it come on five steps: pre design step (Design in Context), analyzing, designing the architectural connection elements, applying the design rules of the connection elements, completing the building design. This technique is a design guideline contains a set of design principles, which can be understood as a series of architectural grammar,

Keywords:

Architecture of Connections, Mamluk, Complex Buildings

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Introduction

The research attempts to illustrate how Mamluk architects at different times and places in the Mamluk eras proceeded to apply the principles of the architecture of connections to the practical problem of space making in Madrasa design, what is called here the ‘inherent design method’, which is a systematic arrangement of the space’s functions to produces the overall design.

Research Problem

From studying and researching Mamluk architecture the research observes that:

- There is no study dedicated to the field of design methods in Mamluk architecture in general and the methodologies of design by connection elements in Madrasa buildings in particular,
- Discussion on the design methods in Mamluk architecture and the necessity of continuing traditional architecture and combining it with the modern architecture has not gained considerable attention among the scholars of this field.

According to that the research problem emerges as a question that this research tries to answer: "What is the design method by which the Mamluk architect had used the architectural connection

elements as a design tool in the design of Madrasa buildings during the Mamluk eras?"

Research Objectives:

The research attempts to reach one main objective which is: **“Discovering the Methodology of Design by the aide of the Connection Elements in Complex Buildings in Mamluk eras”**,

In order to achieve this main objective three sub-objectives have been formulated:

- Demonstrating the Design method and design techniques in the Architecture of Connections.
- Presenting the different design criteria in the architecture of connections.
- Demonstrating the different types of connection elements in Mamluk architecture.

Research hypothesis:

The research based on one main hypotheses, which is “There is a design technique the mamluk architect had depended on it to generate the design of the Madrasa buildings and the architectural connection elements are the reference points for the guideline system of design”

Research Contributions:

The research contribution can be summarized in



four points:

- The research had determined nine of design criteria in the architecture of connections.
- The research had specified twenty elements of connections in the design of Madrasa buildings.
- The research had suggested a generative design technique for Madrasa buildings in Mamluk eras, this helps contemporary architects to understand the design criteria of the architecture of connections for further exploration into more complex design solutions for present needs,
- The design of Madrasas buildings from Mamluk periods had examined to enriching our knowledge of historical design methods and understands Mamluk theories of design besides describing the design method of Madrasa buildings from the maker's point of view,

Research Method:

The research methodology depends on two approaches of thinking:

- The First: outside-inside approach: This approach depends on looking at the building design problem from outside as a whole subject, and then delving inside it to reach its main component.
- The Second: in-out approach: This approach depends on beginning from inside, from the design problem's main component and going out, step by step, to reach the final design.

In order to achieve the research objectives this study is divided into four main parts: The first part is the introduction, which demonstrates the roots of the research problem, the objectives, the research contributions and the research hypothesis. The second part is the theoretical study, which begins with a close look at the design method in the architecture of connections. Then it sheds light on the design criteria and the types of connections elements which were used in the design of Madrasa buildings. The third part presents the methodology of design by connection elements in Mamluk architecture, and the fourth part is the applied study which demonstrates the applying of the suggested technique of design in many case-study of Madrasa buildings.

Theoretical Study

To make a wide background about the architecture of connections in Mamluk architecture, the research in this part discusses three points: firstly demonstrates the design methods in the architecture of connections, then determines the design criteria in the architecture of connections and finally demonstrates the different types of connection elements in Mamluk architecture.

Design method in the Architecture of Connections

No Mamluk artist or architect seems to have left us any writing about his profession, his individual work, his general concepts of art and architecture, or craft schools he might have belonged to, in a manner comparable to the familiar way in which other cultural agents did, especially the Ulama and literati in their assorted array of professions [Rabbat, 1998] p.34. In the building crafts, there seems to have been no single word in the Mamluk period to encompass the meaning of "designer" or "architect" as we understand them today. The term *mi'mar*, used today in most Islamic languages to mean "architect," appears in the Mamluk sources only in the sense of "mason". In the building crafts, the most frequently encountered terms are *mu'alim*, *mi'mar*, and *muhandis*, but in the building design the Mamluk architect gave height attention in design process to the mutual relationship between building's connection elements and their surrounding urban context, this to avoid the conflict between the decision of architects (design demands) and the desires of patrons (owner), so the monumentality of Mamluk buildings reflects the grandeur of the patron's sovereignty, patrons were in some cases involved with the process of design.

The practice of all aspects of construction, formally regulated by the Mamluk sultan al-Nasir Muhammad (1293-1340, with two interruptions), chroniclers of the period attribute to him the establishment of a special department for building (*diwan al-'ama'ir*) to coordinate the multitude of land-reclamation projects and social and religious/charitable structures in which he and his emirs were engaged. [Maqrizi, 1854]p.306. It was then that the *shaddal-'ama'ir* (superintendent of buildings) became a regular title of an important position at the Mamluk court.

Design Criteria in the Architecture of Connections

By studying the methodology of design in the architecture of connections in the Mamluk architecture the research had specify nine of design criteria which the Mamluk architect had depended on them in his methodology of design of the Madrasa buildings, they are as follows:

The Flexibility of Design

There were no researches tried to study the idea of spatial flexibility in Mamlu architecture to find a pattern for designing spaces - Spatial flexibility is defined in the ability to achieve change in conditions without changing the system [Dluhosch, 1974] - although Mamluk historical forms implemented and concluded that the commonality of these centrally oriented forms is the existence of a kind of flexibility in their ambiguous planes. In the design of center-oriented Madrasa buildings, the

courtyard is surrounded by different functions, this enabled users to interpret space in accordance with their needs without changing the capabilities of the courtyard.

In the production of space in Mamluk architecture every function has a specifically defined space. Today Mamluk buildings are not a symbol of static hierarchy; instead, they have become flexible spaces for use by a dynamic community. With regarding to the methods of achieving flexibility in Mamluk architecture, the research specifies two types of architectural flexibility in the architecture of connections: the first is **the flexibility of the user's creature**, this flexibility is based on the user's interpretation of the space according to the user's diverse range of activities, and the second is **the flexibility of the architectural function**: in this type the Mamluk architect intends to design spaces to be with maximum function performance.

Depending on Dynamic Composition

Mamluk architect had generated three types of Dynamic in his building design: the dynamic composition, the dynamic space and the dynamic visual sequences. **The dynamic composition** is that composition that has the ability to generate harmony between many internal forms to appear as integral elements in one body, for example in the

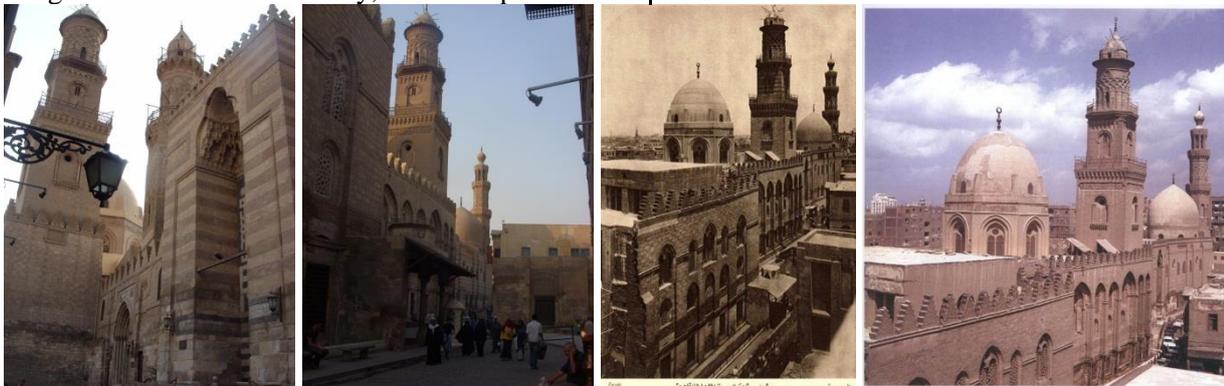


Figure (1) The visual sequence in al-Muizz Street between the Sultan Qalawun School and the Sultan Barquq School from different sides of visions. [(1,2) [Author], (3) [Archnet], (4) [Behrens-Abouseif, 2007]]

Depending on Geometric Composition

This section discusses geometry in the architecture of connection from three points, as follows:

1- The role of geometry in the process of design in the Madrasa buildings

The Mamluk architect had depended in geometry to controls four aspects of the architecture of connections, as follows:

- **The formal aspects:** it determines the geometric rules which control the position of every connection elements inside the whole building layout.
- **The visual aspects:** it determines the geometric visual relationships between every connection

Madrasa of Sarghatmish, the architect has placed two domes and a Minaret on the top of the building's roof, then the entrance comes to extend from the ground to the top of the entire height of the building, all these elements appear as one form which imposes on the user a sense of the dynamism of the composition,

One of the distinctive aspects of Mamluk architecture is the difficulty in determining the beginning and end of the space, for example the space forming the Sahn overlaps with the four Iwans, which makes the user sense that they are a single space unit without the ability to determine the physical separation between the five spaces. This is called dynamic space.

Islamic architecture did not succeed in achieving the dynamic composition, but rather the creativity extended to achieve the dynamic visual continuity over the street path. For example the Madrasa buildings of the Sultan Qalawun and Sultan Muhammad Ibn Qalawun and Sultan Barquq their mutual visual relationships presents a unique dynamic visual sequence, as the movement direction of the user of Al-Muizz street changes when passing in front of these buildings a different visual image will formed, as in the following figures.

elements

- **The spatial aspects:** it determines the geometric relationships between the positioning of every connection element inside the building form with its neighbor
 - **The functional aspects:** it determines the degree of suitability of the spatial form of the connection elements to its function.
- 2- Geometric shapes in the architecture of connections

The Mamluk architect had depended in pure geometric shape in the compositions of the architectural of connections as square and rectangle shapes.

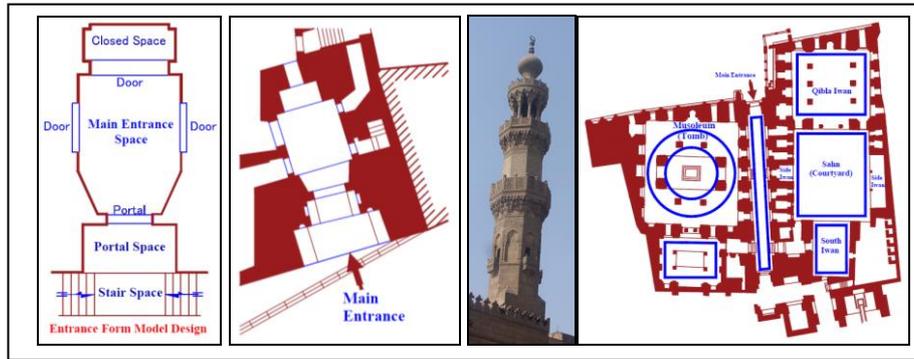


Figure (2): Geometric shapes in the architecture of connections: a- Sultan Qalaun Madrasa, b- entrance composition design, c- The minaret of Qadi Zayn al Din Yahya Madrasa. [Author]

3- Geometric relationships in the architecture of connections

Through the geometric analyses of Madrasa buildings the research determined six of geometric relationships which controls the positioning relationships between connection elements inside

the composition of Madrasa buildings, as follows:

- | | | |
|----------------------------|--------------------------------|------------------------------|
| 1- The Alignment Relations | 2- The Perpendicular Relations | 3- The Tangency Obedience |
| 4- The Parallel Relations | 5- The Angled Relations | 6- The Symmetrical Relations |

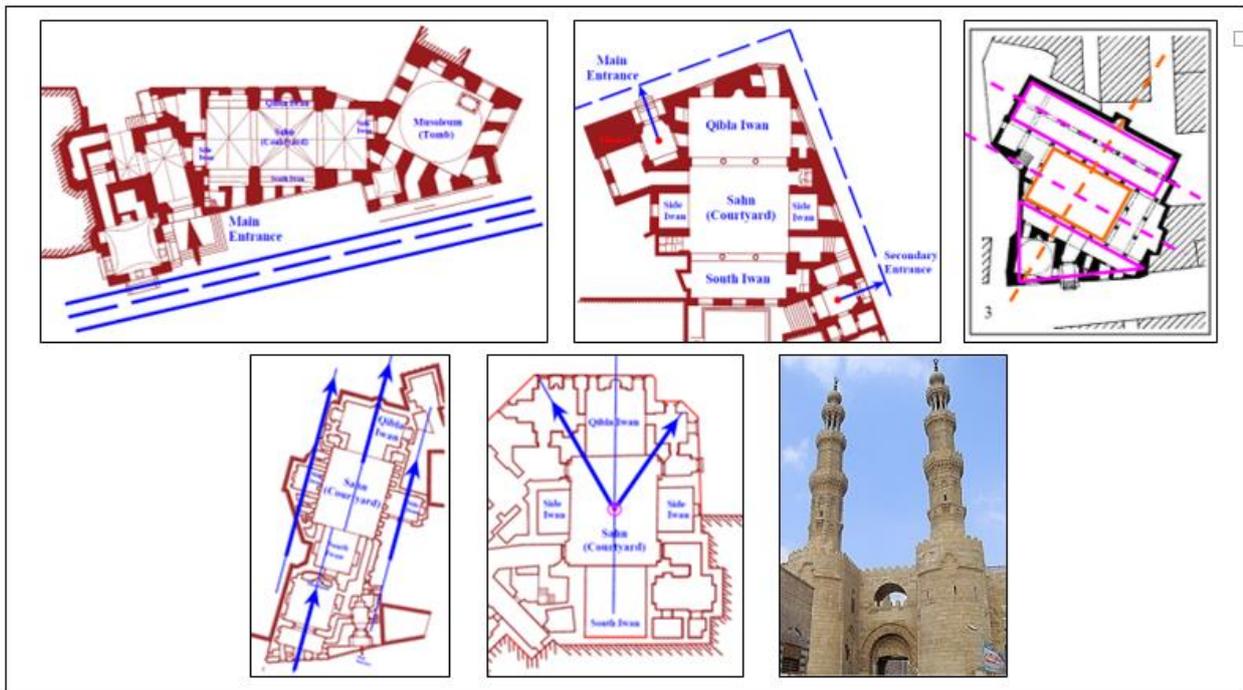


Figure (3) the geometric relations in the architecture of connections in Mamluk Madrasa buildings: left to right: 1- The alignment relation between the building and the street in Emir Khayrbak Madrasa, 2- The perpendicular relation between the street axis and the entrance axis in Emir Azbak al-Yusufi Mosque. 3- Tangency Obedience in Emir Ulmas al-Hajib Mosque, 4- Parallel relation between architectural spaces and the Qibla orientation in Baybars al Jashnakir Khanqah, 5- The angled relation between the courtyard and the Mausoleum in Umm al-Sultan Sha'ban, Madrasa, 6- The symmetrical relation in the Minarets form of Bab Zuweila. [Author].

2-2-1 Depending on Design Continuity

The research had founded that there were three types of design continuity in the architecture of connections in Madrasa buildings, as follows:

1- Visual continuity

The visual continuity in Mamluk architecture can be seen in three positions. The first is the visual continuity in the same building. In this case, the visual continuity occurs in two facades facing two

different streets. The second is the visual continuity between different buildings' facades straddling the same street. The third is the visual continuity between the interior architectural space and the exterior urban space. (Gaber, 2011, p.90).

2- Function continuity

By the analyses of the architecture of connections in Madrasa buildings the research had founded the function continuity in two positions, as follows:

a- The function continuity in the same building and it take three phases:

First: one architectural space serves many architectural functions around it.

Second: one architectural space contain many architectural functions inside it.

Third: two or more spaces complemented to introduce one architectural function

b- The function continuity between different buildings' architectural function.

3- Structure continuity:

This type of continuity can be founded more obviously in the design of structural elements – for example, Minarets and Domes - in architecture of connection it takes two types, as follows:

- Structure continuity in the same building (for example design of the Minaret as one homogeneous architectural unit),
- The structure continuity between different buildings straddling the same street.

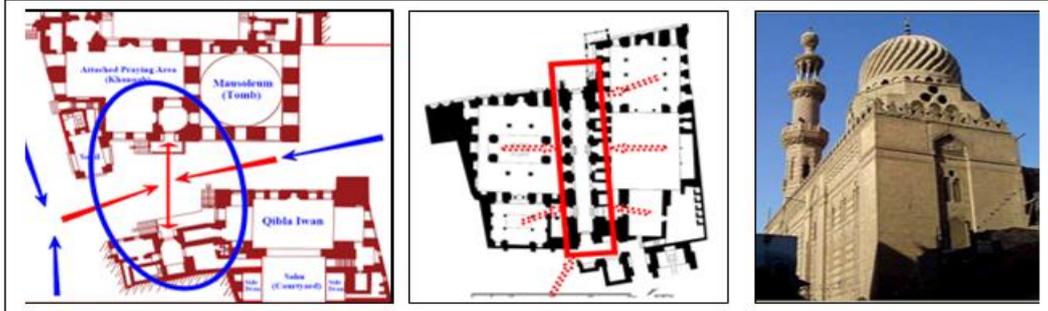


Figure (4) the continuity in the architecture of connections, left to right: 1- The visual continuity through the street in the complex of Sultan Al Ghuri Complex, 2- The function continuity of the corridor in Sultan Qalaun complex, 3- The structure continuity in the Minerate - dome composition in Sultan El Ashraf Barsbay complex, [Author]

2-2-2 Design by Urban Context

An initial reading of Mamluk architecture reveals form qualities governed by urban factors, and, as a result, Mamluk monuments cannot simply be read as containers of spaces or objects in space, but rather as complex mediators between interior architectural spaces and exterior urban spaces. Individually, Mamluk monuments were more responsive to their context than initiators or dictators of new ones. It was from their collective power that a new concept of space emerged. It becomes clear that the concept of space expressed in it is not manifested in isolated buildings but in urban infills (Al-Harithy, 2001, p.73).

Design by urban context Mamluk architecture passed in two steps: the first step is pre design step (Design in Context) in which the designer begins with site analysis to reach a unity in the visual design and avoid any conflict between the building and the surrounding urban context, the result of this

step he can determine the position of the visual connection element (entrance, dome and minaret) in the building design, the second step is analyzing, in which the designer concerned with two factors: the mutual relationship between the building and deviation of surrounding streets and The building deviation from the Qibla direction. When the Mamluk designer in Madrasa buildings selected the position the connection elements those which are in relation with the urban context, he tried to draw an integrated harmonious relationship joining them with the surrounding urban context. This is very clear in the Mosque of Muayyad Shaikh, the designer used the stone bases of Bab Zuweila to place the Mosque's Minarets above them, also in the Emir Shaykhu al-Umari Mosque-khanqah and the Aqsunqur (the Blue Mosque) as a clear example of design by urban context, the architect divided the building into two parts and placed them facing each other across the street.

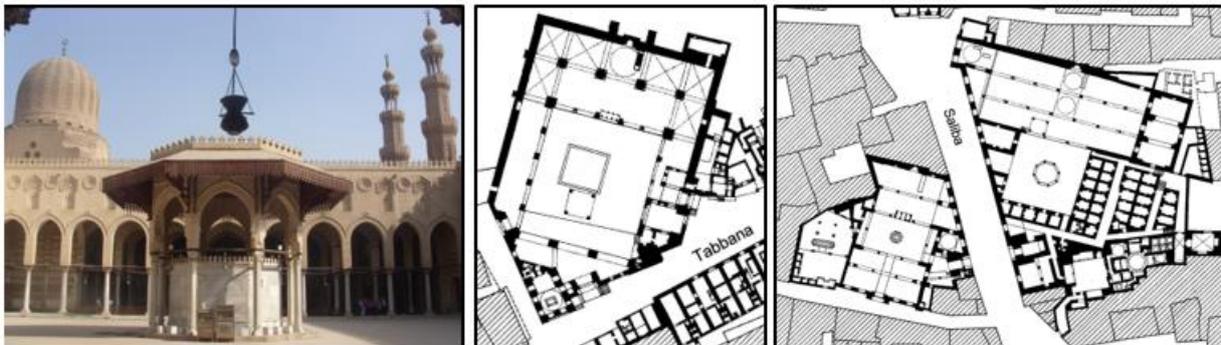


Figure (5) design by urban context in architecture of connections in Mamluk buildings: left to right: 1- Muayyad Shaikh Mosque, 2- Mosque of Aqsunqur al-Nasiri, 3- Mosque of Emir Shaykhu al-Umari. [(1) [Author], (2),(3) [Behrens-Abouseif, 2007]]

2-2-3 Design by Symbolism

Oleg Grabar in his study "Symbols and Signs in Islamic Architecture" formulated some questions as follows: Is there an Islamic system of visually perceptible symbols and signs?, What are the sources of the system, the revealed and theologically or pietistically developed statement of the faith, or the evolution of visual forms over fourteen hundred years? And In what fashion and how successfully were signs and symbols transformed into building forms? The conclusion of this study Oleg Grabar has argued that there was not a system of visual symbols in Islamic culture; in this paper I argue against this proposition I explicate how the architecture of connections as an architectural type embodies uniquely Islamic symbols.

Rudi Paret¹ makes a distinction between primary and secondary symbols. Primary symbols are direct expression of the subject or object being symbolized while secondary symbols are intrinsic in meaning and may represent contradictory states such as life and death, or darkness and light. [Paret, 1958]

The research had founded that there were two sources of symbolism which the Mamluk architect had depended on them in the design of Madrasa buildings, as follows:

1- The symbolism of architectural elements forms and shapes:

- Minaret: symbol of spiritual illumination notion of light.
- Mihrab-Recessed wall: facing towards mecca creating sense of direction, unity, universality
- Arabesque: shows spirituality through proportion, harmony, unity, balance.
- Dome: show god centeredness, connection between earthly and spiritual realms as bring one's attention from ground to God's world
- Interior spaces emptiness leads to spirituality, emphasizing Islamic notion " God cannot be localized to any particular space or time"
- The bow-arch architecture design in the Madrasa induces peace in the worship sites in a way that even a passer-by can receive this peacefulness.

2- The Symbolism of subjects and meanings

Mamluk architect had symbolized a specific subject behind form designs, as follows:

- Architecture is the sensible image of spiritual world, for example most of Madrasa forms present the symbol of plurality in unity and unity in plurality. Plurality is the manifest of

¹ Rudi Paret studies focus expressly on symbols, signs and signification in Islamic culture.

God's attributes represented by plural forms in the design emanated from a united center [Maghbali, 2014].

- Shamsah (sun) is a symbol of divinity, light, and oneness. Mamluk architect reflect the same meaning in the design of the Sahn. God is called light in holy Quran. Hence, Shamsah and Sahn is a symbol of God, the light of skies and the earth [Balkhari, 2005].
- Use of scripts and calligraphy in the architectural ornament is done in the form of inscription and tiles painted. Often the inscriptions reflect the verses of holy Quran and in the eyes of Muslims Quran is the origin of all beauty, happiness, and salvation of humanity.

2-2-4 Complementary between form and function

A large number of scholars have argued that (a) Islamic architecture is hidden, in the sense that its interior is not articulated on the basis of its exterior; (b) the form of Islamic buildings neither expresses nor embodies its function. [Mitias, 2018]. I will present informed arguments against these claims in three points as follows:

1- In Mamluk architecture the relation between form and function is a dynamic interrelatedness based on three criteria:

Firstly: the form is exists, to serve a specific function,

Secondly: the function of a building determines, to a large extent, the kind of form it should, or can, have; and the kind of form the architect conceives will,

Thirdly: where function does not change form does not change, this mean that we could experience Madrasa buildings only from the standpoint of their functional aspect.

2- What makes a building Islamic? A Madrasa buildings are Islamic inasmuch as it embodies in its formal structure the basic beliefs and values that constitute the fabric of Islamic culture. [Mitias, 2018] For example, when we enter the Madrasa buildings, stand in its courtyard and in its prayer hall, and feel the aesthetic presence of the building, we feel, and know, that we are in a mosque, primarily because the structural form within which we move is essentially Islamic in nature. For Mamluk designer the functional aspects, which are in turn reflected in its formal structure. of the building is the alphabet of the language of architecture,

3- From the analysis of the architecture of connections the research had specified five main types of forms the Mamluk architects had depended on them in the design of Madrasa, as follows:

- Rectan
- Circul
- Linear

gular and Square forms - Octago

ar form - Hexag

form - Volum

nal forms

onal form

etric form

The following table presents the complementary between these forms and its functions in the architecture of connections in Madrasa buildings.

The Architectural Elements	The Function	The Form
The entrance	- Connection between inside and out side	Volumetric form
The Minaret	- Orienting the pedestrians (Landmark of the city)	Linear form
The Mausoleum	- Funerary functions	Square form
The Dome	Religious and Secular purposes	Circular form

Table (1) The complementary between form and function in the architecture of connections. [Author]

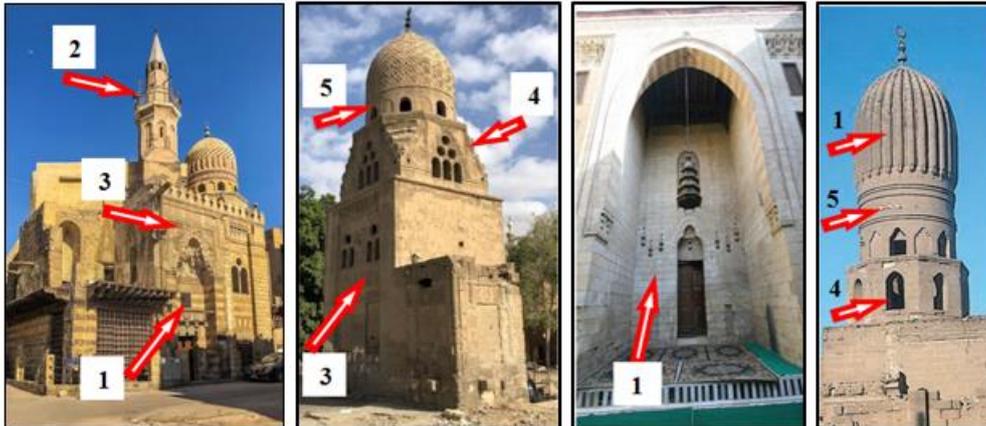


Figure (6) Relationship between form and function: from left to right: 1- Asfour dome in Mamluk cemetery, 2- Side iwan in Madrasa of Sultan Barsbay, 3- Mausoleum of Amir Yunus al-Dawadar. [Author]:

1: Volumetric form, 2: Linear form, 3: Square form, 4: Octagonal form, 5: Circular form.

As a conclusion of this section the research argued that:

firstly, Islamic architecture is manifest not hidden, in the sense that its interior is articulated on the basis of its exterior; and consequently the exterior of the building reveal its interior or identity; and that, secondly, the form of the Madrasa building express or embody its function; that is, there is a causal relation between its form and function, in other words: the buildings that Muslims use are Islamic in terms of their physical structure, thirdly, Madrasa buildings can be identified not by its formal structure, but by a multiplicity of symbols, fourthly: there is height necessary connection between the look of the buildings on the outside and the inside because the exterior is articulated on the basis of its interior and vice versa.

2-2-5 Design by centrality

In Mamluk architecture there are two main types of centrality:

- Centrality in building design: the courtyard is the generating centre of the building design
- Centrality in city developing: throughout centuries the Islamic cities was developed around the mosque and corresponds to it,

The analysis of Madrasa buildings shows that the design of the plan was based on the direction

towards the inside, (introversion), and that tow patterns are predominant: the first is the courtyard surrounded by riwaqs; The second is the Madrasa with four Iwans surrounding a central courtyard. ((OICC),1992, p.159). Design by centrality in the architecture of connections is reflected on building design in two points: first: the most important architectural space must be placed in the center of the building, second: all other architectural spaces in the building must be distributed and wrapped around it.

The Mamluk architect depended on the point as a primary element of the building form generation process, which helped him reach the unity of space. This was achieved by the conformity of the orientation of the whole composition to the centre. This centre generated an ordering force onto the whole composition of the building. This point is vital to understand the importance of the centre as the point of beginning and end in the conception of Muslim medieval religious building [Gabr,1992]p.453. the center point is the "Reference point" which actually all the building design revolve around it, like the point of falling down ston in the water, from this point all waves go and extractes and refer to it. [Gaber, 2018]. The centre of the Sahn in the overall plan of the Madrasa was the visual centre and the most logical starting point for its design.



Figure (7) design by centrality in the architecture of connections, left to right: 1- the courtyard in Sultan Barquq Madrasa, 2- the centre point in the Mamluk buildings in El Muiez street, 3- the centrality in El Ashraf Barsbay Madrasa. [(1), (3) [Author], (2) [Behrens-Abouseif, 2007]]

2-2-6 Design by Articulation

Articulation, in architecture, is a method of styling the joints in the formal elements of architectural design. [wikipedia]. The articulation of a building reveals how the parts fit into the whole by emphasizing each part separately. Mamluk architect had depended in the design of Madrasa buildings on two types of articulation form as follows:

The first: The corner articulation form

In the corner articulation form Mamluk architect had depended on four spatial rules of formation:

- 1- The strongest, definition and clarity of the

corner articulation form of depends on how its surfaces meet each other at corners, and how resolving the relationships between these edges

- 2- The role of the corner configuration in the overall composition of the building depends on the visual treatment of the adjacent and adjoining surfaces.
- 3- Emphasizing the continuity of the bounding surfaces of a form and softness of its contour requires rounding off the corner.
- 4- In order to confirm the visual continuity of the corner form, it must have no fenestrations.



Figure (8) the corner articulation form in Madrasa buildings, left to right: 1- Mosque of Qajmas al-Ishaqi, 2- Mosque of Ilgay al-Yusufi, 3- Faraj Ibn Barquq Khanqah, 4- Complex of Sultan al-Ghuri. (1,2,3) [Author], (4) [Archnet]

The second: The axial articulation form

In Mamluk Madrasa buildings there is a main axis all the building spaces and forms are articulated around it. This articulation axis is the hidden and the secret factor which connects the building plan

design with the building facade design.. In architecture of connections the axial articulated forms mainly express visually their individuality to define its shape and volume.

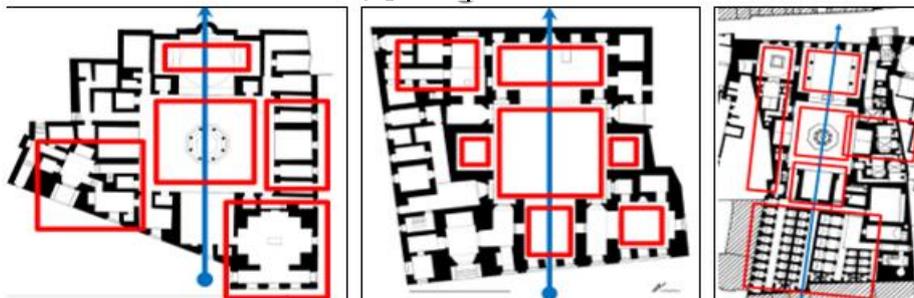


Figure (9) The axial articulation form in Mamluk architecture of connections, left to right: 1- Amir Sarghatmich Madrasa, 2- Sultan Ylgay Al Yusufi Madrasa, 3- Complex of Sultan Barquq. [Author]

2-3 Types of Connection Elements in Mamluk Architecture

The Mamluk architect had distributed the connection elements in the design of Madrasa building in two places: inside the building or in-between inside and outside the building. The

research had determined twenty of connection elements in Mamluk architecture distributed in four main categories, as shown in the following table.

1- The Functional Connections Elements		
1- The Entrance	2- The Sahn (Courtyard)	3- The Sabil-Kuttab
4- The Corridors and Stairs	5- The Wind Catcher	
2- The Visual Connection Elements		
1- The Minaret	2- The Dome	3- The Fenestration system
4- The Urban Wall	5- The Paths	
3- The Meaning Connection Elements		
1- The symbolism of the Center Point	2- The symbolism of the Court	3- The symbolism of the Mausoleum
4- The symbolism of the Dome	5- The symbolism of the Minaret	
4- The Construction Connection Elements		
1- The Arches	2- The Hang stone	3- The Shoulders
4- The Wood Ribs	5- The Squinsh (Muqarnas)	

Table (3) types of the connection elements in Maluk architecture. [Author]

2-3-1 The Functional Connections Elements

This type of connections linked between different functions, they can be determined as follows:

2-3-1-1 The Entrance

From the analysis of the entrance as a connection element in the Mamluk Madrasa buildings it is found that, a single pattern can be presented for the placement of spaces in relation to each other from the entrance to the courtyard. The most hierarchy pattern of entrance usually consists of six components: the frontage is the first space that prepares utilitarian to enter a space with different characteristics. After passing through the frontage, it is necessary for the utilitarian to pass

through the antechamber and the passageway. The antechamber is the station of disconnection from the world and is a little backward to its adjacent space. After the antechamber, the doorway passes the user from the previous stages to the next ones. Following the passage of the doorway of Madrasa, it leads to the vestibule (bent corridor). This space is different from the previous spaces and stages. If the previous space calls the utilitarian to pass through, this space calls for a pause in terms of its geometric form. After the vestibule is the hallway. The hallway is usually a narrower and darker space than the vestibule. The hallway leads to the courtyard, as shown in the following figures.

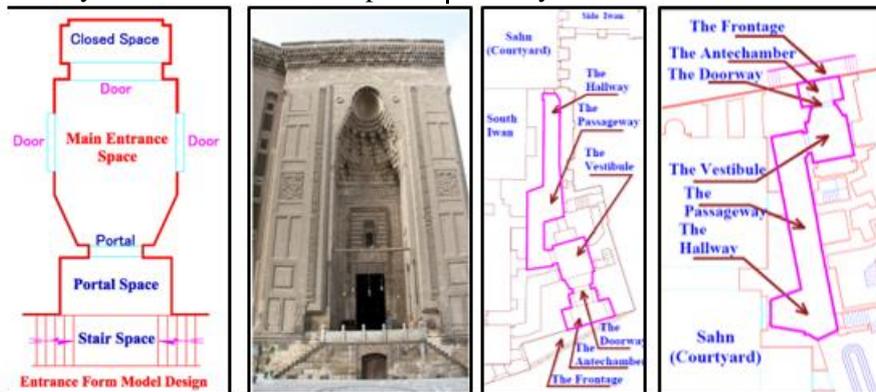


Figure (10) The components of the entrance as a connection element, left to right: 1- The entrance form design in Mamluk Madrasa buildings, 2- Sultan Hassan complex, 3- Sultan Baybars al-Jashankir Complex, 4- Al Ashraf Barsbay Madrasa, [Author]

2-3-1-2 The Sahn (Courtyard)

In the architecture of connections the courtyard is a connection element to all function around it, and provides users with the opportunity to enjoy a private open space with green elements.

By the choice of the courtyard as the heart of any traditional building, the traditional designer obtained a more feasible “urban” form, capable of providing that basic contact with nature so essential to traditional Muslim life. This architectural tool

dominated the architectural activity of “place making” and within the Islamic medieval period in Egypt became the prototype of place, unifying the individual parts of a building with the whole. Within tranquil sahn, the placement of the traditional water fountain with all its attributes and abstractions provides a centre which acts as a generator of form. The whole organization of medieval Islamic buildings seems to start from that centre extending the design outwards.

[Gabr,1992]p.353.

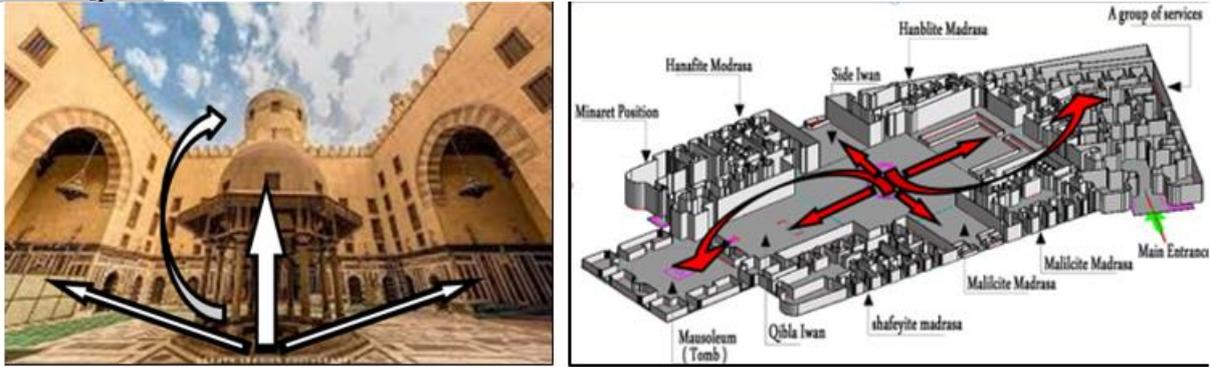


Figure (11) the courtyard as a connection element, left to right: 1- Amir Sarghitmish Funerary Complex, 2- Sultan Hassan Complex. [Author]

2-3-1-3 The Sabil-Kuttab

Sabil is a facility that provided free, fresh water to thirsty passersby and Kuttaba is primitive elementary schools that teach children to read and write and also it is a Qur'anic school for boys. Architecture of Mamluk period has been distinguished by the grouping of the Sabil and Kuttab in one block attached to the educational institutes, or in an independent building. On top of the Sabil would be the kuttab, with its facade as a wooden balcony with arches, topped by a projecting roof leaning downwards.

The Sabil-kuttab forms a significant part of the

design and now become a distinct feature in Mamluk architecture. Their popularity continued well into the Ottoman period when they frequently appeared in free-standing form, contributing enormously to the character of Cairo's urban landscape [Yeomans, 2006]p.224. To be effective in its role as a connection element the position of establishing the public Sabil-kuttabs, when they were attached to educational institutions was selected with high accuracy at the corner of the building to form a unified volumetric composition, or separated in an isolated building.

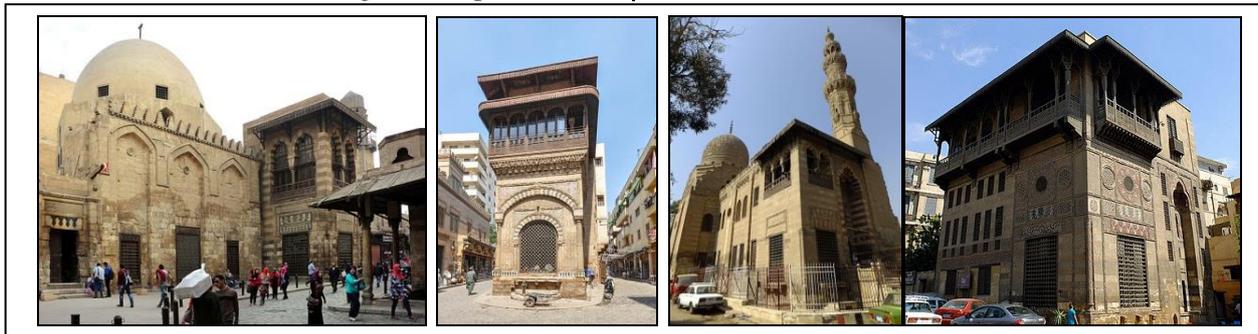


Figure (12) The Sabil-Kuttab form as a connection element in Mamluk architecture, left to right: 1- Sabil-Kuttab of Sultan Qaytbay, 2- Madrasa-Mausoleum of Al Salih Najm ad-Din Ayyub, 3- Sabil-Kuttab of Katkhuda, 4- Complex of Sultan al-Ashraf Qaytbay. [Author]

2-3-1-4 The Corridors and Stairs

The corridors in Madrasa buildings organize structure of the plan. There are two types of corridors in Madrasa buildings: the main corridor which connects the entrance to the courtyard, and the secondary corridor which connects between the courtyard and the all other functions.

The offset corridor followed the entrance hall leaves the visitors' senses shocked by the sudden changes: from the noisy street to silence, from light to dark, and from heat to coolness. As the body needs to accommodate physically to these changes, so does the soul to be able to attain the state of mind to the Hands of God. [Gabr,1992]p346 It maintained completely privacy and reduce noise level for the building so we can name it "the dark corridor". In Sultan Qalaun the entrance was

extended by a corridor, the corridor divided the plan into two compositions, the corridor was treated as streets and the real entrance within the corridor was hardly recognized due to the narrowness of the corridor without any significant space in front of the entrance, but at the Khanka of Baybars al Jashanqir the entrance was directed to the court through a corridor, the entrance has become larger than the corridor and has an access opening to it.

Stairs in Mamluk architecture play the role of moving connection element between different levels inside the building and one of the most interested features on the design of stairs in Madrasa buildings is, it is designed as electronic stairs, it has no fixed place, but every level of floor have his individual stair which connecting it to the upper level.

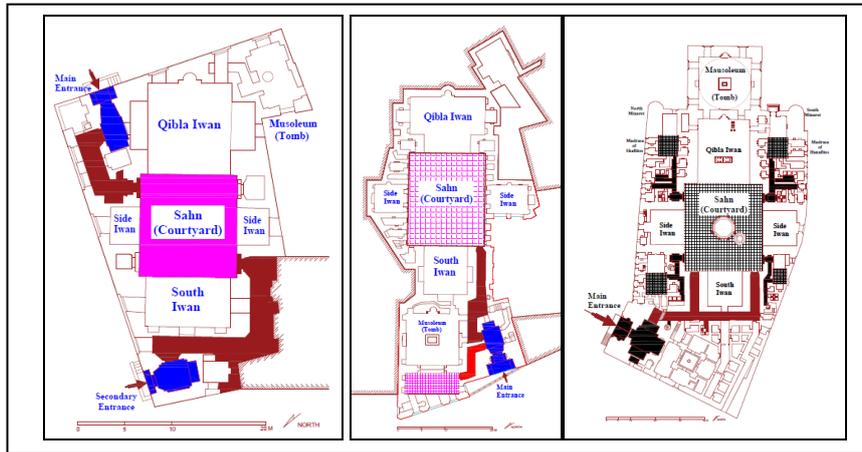


Figure (13) The corridor as a connection elements in Madrasa buildings, left to right: 1- Sultan al-Nasir Hasan Complex, 2- Qadi 'Abd al-Basit Mosque and Madrasa, 3- Sultan Baybars al-Jashankir Complex. [Author]

2-3-1-5 The Wind Catcher (Malqaf)

In Mamluk architecture the wind catcher are known as *malqaf*, They are generally shaped as right triangular prisms with the vertical side left open and facing directly up or down wind. They work best if oriented within 10 degrees of wind direction; larger angles allow the wind to escape. [Attia, 2009]. The Malqaf is an important

bioclimatic connection archetype creates natural ventilation and passive cooling inside the buildings, so it defined as: an architecture element that used to ventilate the building. In Khanqah of Baybars al-Jashankir the designer place the Malqaf directly over a roof opening to channel the airflow into the building, it can be seen in five places in the building as in the following figure.



Figure (14) wind catcher in Madrasa buildings, left to right: 1- the structure of the wind catcher, 2- the position of wind catcher in Khanqah of Baybars al-Jashankir. [Author]

2-3-2 The Visual Connection Elements

It is much more difficult to identify the operation of the visual code in the past than to understand practical function. It has often been noted that the specific function of many Mamluk buildings – *Madrasa, Khanqah, ribat, masjid, jami*, even at times hospital or warehouse – is difficult to identify by visual observation alone, by the simple perceptions of its gate or façade. Most of those buildings use a small number of architectural themes which are the ones dominating the city's landscape, most particularly minarets, domes and gates. They are the real, continuous, architecture of Cairo much more than the function they house...What has been provided in the city of Cairo is a network of visual signs which orders movement within the city and which makes it physically usable and understandable, whenever one tries to use and understand it. [Grabar, 1984]p12. The

research had specified five of visual connection elements in Mamluk architecture, as follows:

2-3-2-1 The Minaret

Three words have been employed in Arabic to denote Minarets: *midhana, sauma'a*, and *manara*. The word *midhana* is derived from *adhan* ("call to prayer") and means, in effect, "the place where the call to prayer is pronounced." The other term, *manara*, means "candle-stick," or "a place in which to place a light." The Minaret performs not only the function of calling the faithful to prayer, but also that of illuminating their way and the way of the stranger to the mosque. [Mitias, 2018]

From connection point of view, in appearance, the Minarets of Cairo vary tremendously. There are short minarets and tall Minarets, double-headed minarets and even quadrupled Minarets. There are several Minarets on the same street, they never seem to obstruct each other; to the contrary, they seem to come together, providing what seems to be

a natural contentment in the eye of the beholder. This leads us to ask if there were town planners in those days or not?. The research had founded that there are five types of connections related to the position of the Minaret in the building design: the

visual connection Minaret-Street, the visual connection Minaret-Minaret, the visual connection Minaret-Entrance, the visual connection Minaret-Dome, the visual connection Minaret-Courtyard, as shown in the following figures.

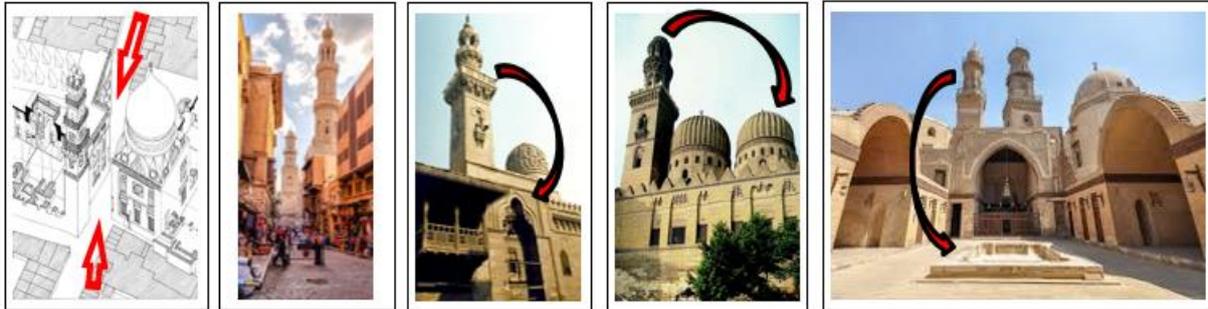


Figure (15) Types of connections between the Minaret and building components, left to right: 1- Complex of Sultan al-Ghuri (Minaret-Street), 2- Minaret of Sultan Barquq Madrasa and Minaret of Sultan Qalaun complex, 3- Mosque of Taghribardi (Minaret-Entrance), 4- The khanqah of Amir Sanjar al-Jawli. (Minaret-Dome), 5- The courtyard of sultan al Nasir Mohamed and Minaret of Sultn Qalaun. [(1) [Behrens-Abouseif, 2007], (2,3,4,5) [Author]].

The Dome

From the architectural point of view, there are two types of domes that were used frequently almost in all of Cairo’s Islamic buildings, the spherical dome (based on a perfect sphere) and the elliptical dome (based on a spheroid). The two terms Squinches and Pendentives, the only two methods used historically to support the domes in Islamic architecture generally and in Madrasa architecture in particular [Elkhateeb, 2012].

A striking visual connection statement is produced in Amir Sarghitmish Funerary Complex in Cairo by the projection of the dome above the mausoleum into the busy street through a rectangular cross-vaulted space. This Madrasa shows how the desire to reconcile the facade to the

existing street alignment while orienting the interior to the Qibla, and the desire to display the Mausoleum to the passersby to invoke their blessings produced a unique volumetric connection composition which provides a rich sequential experience on both the interior and exterior.

To be effective in its role as connection elements the Mamluk architect had placed the dome in prestigious place in the main façade of the building adjacent to the street. This lead to generate four visual connection relationships: the visual connection Dome-Street, the visual connection Dome-Dome, the visual connection Dome-Minaret, the visual connection Dome-Entrance, as shown in the following figures.

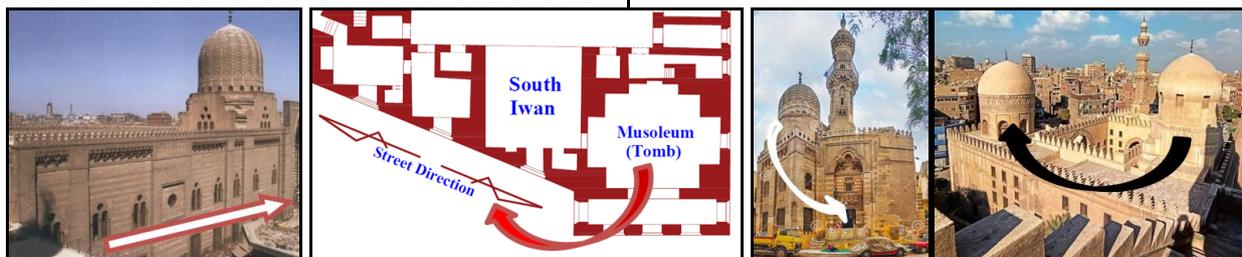


Figure (16) the dome as a connection element in Madrasa buildings, left to right: 1- Complex of al-Mu’ayyad Shaykh (the Dome-street visual connection), 2,3- Amir Sarghitmish Complex (2- Dome-Street visual connection, 3- Dome-Dome visual connection), 4- Mosque of Qanibay al-Muhammadi (Dome-Minaret and Dome-Entrance visual connection). [Author]

The Fenestration system

Window is one of components which play a salient role in shaping the building in Mamluk architecture. The function of fenestration systems in Madrasa buildings was supplying with light, curtailing sunlight intensity, establishing beauty in building façade, besides serving the visual transition by the eyes from inside to outside as a kind of visual communication with the street.

To be effective in its role as connection elements

Mamluk architect changed the type of fenestration system according to its place in the building, the research had founded that there are seven types of fenestration system as a connection element in Madrasa buildings, as follows:

- **Fenestration system of Qibla wall:** it is always square area in the center of which lies the Mihrab and in both sides are two arches each one is end with a window, topped by an elongated grill with the Mihrab’s round

Qamariya in between.

- **Fenestration system of the Minaret:** always vertical windows inside rectangular niches which up to the full height of the Minaret ending on top by stalactites.
- **Fenestration system of the Mausoleum:** it is square area covered with dome, the windows were placed in the dome's transitional area.
- **Fenestration system of the street façade:** The external façade is marked with vertical rectangular niches with pointed arches filled with rectangular windows.
- **Fenestration system of inner facades:** The facades which overlook the courtyard, its fenestration system always is tall rectangular

windows inside niches crowned by stalactites.

- **Fenestration system of the Entrance:** The entrance is a deep rectangular niches crowned by rows of stalactites and trefoil arch. In the forefront of the rectangular niche would be a door and on top would be a window.
- **Fenestration system of the Sabil-kuttab:** Usually the Sabil is placed in the corner of the building, and has two or three windows according to its location with relation to the surrounding streets. On top of the Sabil would be the kuttab, with its façade as a wooden balcony with arches.

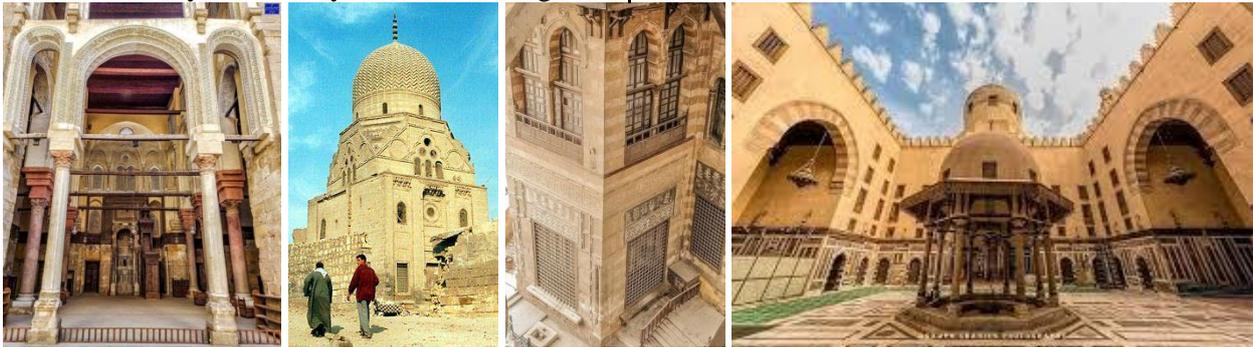


Figure (17): Fenestration system in Madrasa buildings, left to right: 1- Qibla wall In Qalaun complex, 2- Mausolum of Amir Akhur's Mosque, 3- Sabil-Kuttab in Complex of Sultan al-Ghuri, 4- Inner facades in Amir Sarghitmish Complex. [Author]

2-3-2-2 The Urban Wall

The urban wall is the building outer wall, which separating and connecting between the building's interior design and the outer site urban design, it is a wall which play the role of the secret agent which accommodate between the interior architecture design and the site circumstances through generating a soft connection relationship between them. These urban walls emerges when the building site is an awkward shape or turning inside spaces to

Qibla direction⁶, or when the main spaces of the buildings has to be an angle to the street. The Mamluk architect depended on the thickness of wall to to avoid the negative effect of the deformation on the enclosed designed space. The architect respect the street orientation from the outside and the direction of the Qibla from the inside, a matter which led to the variation of walls' thickness, [Gaber, 2018]

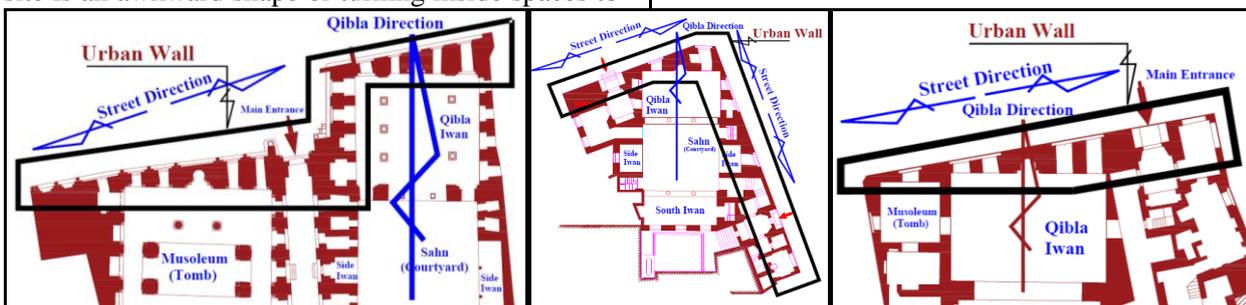


Figure (18) urban wall design in Madrasa buildings, left to right: 1- complex of Sultan Qalawun, 2- Madrasa of Qadi Abu Bakr Muzhir, 3- Al Ashraf Barsbay Madrasa. [Author]

2-3-2-3 The Paths

The image of the streets network in Cairo of the Mamluks demonstrated two types of roads: the first type was called '*Qasapa*' which extended from north to south and carried most of the commercial activities. The second type went from east to west and led to the main gates of the city. [Moubarak, 2020]p.545. The visual connection in paths can be

understood as fluid, activated by the physical movement of users and marked by orientation locations. As emphasized by Kevin Lynch, visual connections are necessary for orientation, and for creating a coherent picture of an urban setting.

From analyzing the Madrasa buildings the research had founded that the visual connection through paths can be seen in three positions, in the

same building, between different buildings' facades and between the interior architectural space and the exterior urban space. To make effective visual connection through the paths, the Mamluk architect had depended in five connection components spreading on the path, they are: the edges, the nodes, the districts, the landmarks, and the building facades, and the research will concentrate in three of them.

1- The Edges:

In the corner articulation style in Madrasa buildings a related problem was that narrow streets tend to detract from the visual impact of a building façade. This was overcome by the use of recessed entrances, domes, and projecting corners which have a cumulative effect of a staggered façade which can be viewed from a side (Petersen,1999)p.174. This dynamic edge plays an important role in improving the legibility of the image and creating the sense of identity.

2- The Urban Nodes and Urban Pocket:

Urban nodes in Mamluk architecture are not entirely defined by structures such as a prominent building or a monument. Mamluk architect not only provide a node for human activities but also act as a focus for paths. Mamluk architect had connected strongly every node via a multiplicity of irregular paths. There were two types of nodes the main public node (the area surrounding the Madrasa buildings) which can be determined empirically, and the local nodes (the courtyards of the Madrasa buildings)

The "urban pocket" is a spatial pause along major spines or paths. The purpose of such an

expansion was to reorient the observer, to acknowledge an entry into a building, or to generate a place of social interaction [Al-Harithy,2001]p.84. In the design of Madrasa of Jaqmaq which squeezed in the street of Darb Sa'ada, the formation of nodes is so clear; its facade forming an angle. The portal and the Sabil-Kuttab are on one side and the minaret on the other, forming an urban pocket between them.

3- The Districts

In Cairo of the Mamluks the districts are the areas whose central nodes are the congregational mosques. The main feature of the districts structure in the Mamluk eras is the clear separation of commercial areas and residential areas. All markets occupied the central district which did not include any residential uses [Raymond, 1994]. This sharp segregation between the residential and commercial quarters in the classic Islamic cities has been attributed to the need for privacy to the houses and this separation helped to gain height visual connection all over the city districts.

In Madrasa of Sultan al-Ghuri the visual connection formed between the building two parts across the street, it has a remarkable layout as a double architectural composition, with two blocks straddling the main street in the heart of medieval Cairo. The western block consists of a mosque with its minaret; the eastern one is a funerary complex. The facades of the two buildings display two projections, that of the minaret on the south-western corner and that of the Sabil-kuttab on the opposite one forming a highly visual connection districts.

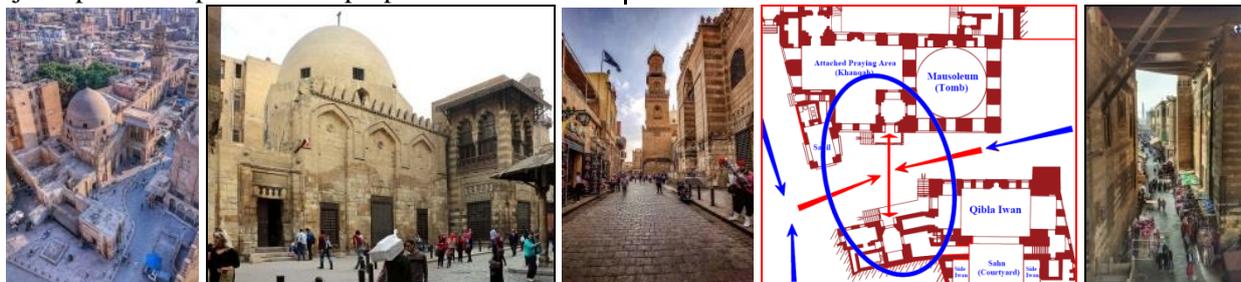


Figure (19) street as connection elements in Cairo of the Mamluks, left to right: 1,2- nodes and districts in front of Sulatn Qalaun complex, 3- edges in el Muiez street, 4,5- urban pocket in front of El Ghuri complex.

[Author]

2-3-3 The Meaning Connection Elements

The Mamluk architect look to building design from three points: what to show, what to leave out and how to translate ideas into built-form. This lead us to an important question: what is the role of symbolism in the architecture of connections in Madrasa buildings?.

The symbolism behind the architecture of connections are primarily conveyed through particular forms, and represented much more than the material manifestation of a physical function.

Each form is charged by its symbolism, which could be symbol of power or divinity. These symbols do not represent the same meaning of the form having the same functions in different buildings. The Mamluk designers always change and develop new forms, new meanings, and new functions due to the flexibility of their design. [Tantawy,2002] p105 It obvious that the Mamluk architects were concerned with the meaning of the architectural element and not the architectural element itself,

2-3-3-1 The Symbolism of the Center Point

The Ka'ba, can be looked at as a centre of a wheel which radiates imaginary lines that link every place on earth, also the heart can be looked as a centre of the body which all parts connected to it. In Mamluk eras Madrasa building were considered to be the centre and the heart of the traditional Islamic cities. The centre point is the "point of communication" between man and building also the communication between divine and human levels of existence.

Madrasas offer a spatial experience, concealing the interior of the building from the outside. The geometric cruciform of a madrassa is only revealed after one reaches its center. Regardless of the directional location of the entrance at the main street and the internal positioning of the courtyard, the visitor is always navigated to the central court, establishing an experiential rule that governed the whole building. [Malhis, 2015]

2-3-3-2 The Symbolism of the Courtyard (Sahn)

The prototype of traditional medieval buildings in Egypt was a hollowed cube, turning blind, windowless to the outside, with all spaces of the building looking inwards into a courtyard from which only the sky can be seen. In the courtyard the spirituality of the building was constantly replenished from heaven. [Gabr, 1992]p347

By the choice of the courtyard as the heart of almost Madrasa building, the Mamluk designers obtained a more feasible "urban" form, capable of providing that the courtyard in religious building design acts as a generator of form, and the whole organization of the building form starts from the courtyard centre extending the design outwards. This indicate the symbolize of the courtyard in the building as the heart in the human body.

2-3-3-3 The symbolism of the Mausoleum

Mamluks built burial domed chambers in prominent sites and associated them with public institutions by "connecting the memorial for the patron with the functional program of a socio-religious institution, [Al-Harithy,2001]. The Mausoleum became a major architectural type that played an essential part in the establishment of the Mamluk Madrassa complexes. Mausoleum as a funerary space should be oriented to Mecca, and should have openings on the façade that follows the alignment of the street "for seating Qur'an readers who were to read day and night", and the internal arrangement should be symmetrical so the designers always construct the Mausoleum on the street side next to Qibla-iwan, or in the corner of the building on the main facade with a prominent dome.

While the composition of Mamluk monuments varied, the funerary dome and minaret were constant leitmotifs. They arose in Cairo as

respective symbols of commemoration and worship; the harmonious combination of Mausoleum and Minaret created a distinctive skyline for the city. This composition, unprecedented either in Fatimid or Ayyubid architecture, where funerary monuments played a less significant role, became a characteristic visual attribute of the Mamluks, almost as much as the blazon [Behrens-Abouseif,2007]p.71.

2-3-3-4 The symbolism of the Dome

To face the vastness of spaces the Mamluk architect used domes in roofing spaces with the Muqarnas aids. In Mamluk architecture the dome provided a symbol of the dome of the heavens, because the roof over building was similar to the sky which covers the whole world. The Dome is the best element indicates 'Unity in multiplicity' and "Multiplicity in Unity" –since the unit is the same and by its repetition and assembling in different ways, it is possible to produce a multiplicity of spatial forms.

2-3-3-5 The Symbolism of the Minaret

Minaret in architecture of connections is that part of the building which reaches for the sky. To make the minaret lead the vision upwards, the Mamluk architect used the inherent qualities of geometry in his design. It is divided into sections, each one shorter than the other as we go upwards, then the eye moves by inertia from the longer sections to the shorter [Gabr, 1992]p.378. In Mamluk architecture the cause for building the Minaret was its utilitarian function and for its symbolic value, the Minaret as a connection element can be explained as "landmark" or "guid-post", so all monuments invariably have their Minarets located next to their portals

2-3-4 The Structure Connection Elements

In the architecture of connections there are many considerable numbers of elements that originally had a structural connection purposes were transformed into purely decorative devices. The research specified five of the structure connection elements in Madrasa buildings as follows:

The Arches: When any ruler builds a building impregnable or raises a portico high, he has his own name and titles inscribed on the arch in order that, as long as the arch remains, his name may remain therein. [Thackston, 1989]p.371 The use of arches in Madrasa buildings is to carry the roof and the dome which they support. Its form is consists of two parts: a quadrangular base and a carved top.

The Hang stone: The most important part of any opening in the masonry is the treatment of its upper part. The two basic solutions to this are either an arch or lintel. The hang stone always placed in the upper point of the opening, which connecting the two sides of the arches. It is the most important visible part of the arch so it takes a height accuracy

of design in Madrasa.

The Shoulders: Shoulders were used extensively in Mamluk architecture as structural elements in minarets to solve the transition between different stations, especially when the minaret consists of many stations with different geometric shapes as in Sultan Barquq Madrasa the Minaret consisting of a square base followed by an octagonal shaft, then a circular shaft.

The Wood Ribs: Wood is used for covering the corridor that follows the entrance and Iwans. Wooden roofs usually consists of ribs, beams and panels, as in Qibla Iwan and Mausoleum in Sultan Qalaun complex

The Squinsh (Muqarnas): The single most common architectonic element used in the decoration of Islamic architecture is the Muqarnas: the stalactite or honeycomb construction. Basically, it is composed of units, each of which is a section of vault, arranged in rows corbeled on top of each other. The units of Muqarnas could be made of wood, stone, ceramics, or stucco. The Muqarnas

provided a flexible way to articulate surfaces and to create three-dimensional ornamental effects that would tend to dematerialize the solidity of forms. In addition, it could be scaled to any need, from vast niches, entrances, or domes to the smallest details of construction or decoration. Some examples of the Muqarnas from the eleventh or twelfth centuries indicate their original structural significance, but quite soon their decorative function at intersecting angles of surfaces became predominant. [Rashid, 2020]. Muqarnas almost composed of progressively projecting tiers of niche-like geometric elements. The Squinches and pendentives actually supports domes, and created a visual transition between such elements as the underside of the Minaret balcony. Like other elements of Islamic architecture, the broad appeal of the Muqarnas may lie in its inherent ambiguity, for its geometric underpinnings delight the mind even as its visual characteristics delight the eye and inspire the soul [Gaber, 2011]p99



Figure (20): Different structural connection elements in Mamluk religious buildings, left to right: 1- Muqarnas in the portal of Ahmad al-Mihmandar Mosque, 2- Shoulders in the minaret of Qadi Zayn al Din Yahya Madrasa, 3,4- Wood ceilings: (Qibla Iwan in complex of Sultan al-Ghuri, the Mausoleum in Madrasa of Sultan Qala'un. [Author]

2-4 The methodology of design by connection elements in Mamluk architecture

In this part the research presents the generative technique of building design by the aide of connection elements in Mamluk architecture

5-1 The generative technique description

Drawings were not seen as essential to the processes of design in medieval Islam. [Yousefi, 2005] p.19, from this notion the research suggests this technique which is a fixed consequence steps to generate the building plan design.

5-2 The generative technique idea

The generative technique extracted its ideas from two points

- 1- The analysis of the architecture of connection in Madrasa buildings presents that there are connection elements which repeated to generate the building whole design.
- 2- The analysis of the Mamluk urban context presents that the designer relies heavily on the visual connection elements (outside the building) and function connection elements (inside the building) as ‘The point of

departure in the architecture design’.

5-3 The generative technique steps

The generative technique of building design by the aide of connection elements in Mamluk architecture had come on five main steps as follows:

1- Pre design step: Design in Context

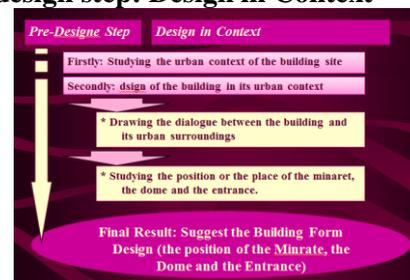


Figure (21): Pre design step procedures [Author]

In this step the designer begins with site analysis by studying the urban context of the building site. Secondly, he studies how the building will fit into its urban context in order to reach a unity in the visual design and avoid any conflict between the building and the surrounding urban context. He can reach visual continuity of the urban context by drawing of a dialogue between the building and its

urban surroundings, and this will be done by studying the place of the entrance, the minaret and the tomb dome in the building, because these three elements are responsible about the visual connection of the building with the surrounding urban context.

2- Analyzing:

The designer concerned in this step with the analysis of the mutual relationship between the building and two main points:

- The building deviation from the surrounding streets
- The building deviation from the Qibla direction

3- Designing the architectural connection elements (the position, form and composition.)

In this step the designer determines two important things:

- 1- First, he determines the relationships between the different functions inside the building.
- 2- Second, he determines the users' circulations diagram

As a result of this step the designer can determine the primary position, form and composition of the different connection elements inside the building, such as corridors and stairs.

4- Applying: Applying the design rules of the connection elements

The designer applies the visual connection rules, functions connection rules and meaning connection rules. The rules of orientation between all of them can be presented as follows:

The Entrance: The entrance is **oriented to be perpendicular** on the street

The Corridor: the corridor is oriented to be **perpendicular** on the entrance and the Sahn

The Sahn and the Iwans: they must be **oriented to be parallel** to the Qibla direction

The Mausoleum' dome and the Minerate: Mausoleum' dome and Minerate must be oriented to be **parallel** to the Qibla direction and **perpendicular** on the street in the same time

5- Completing the building design

By placing the attached architectural spaces the Mamluk designer could generate the final design of the building.

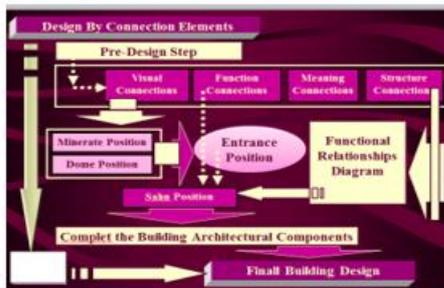


Figure (22) The Methodology of Design by Connection Elements. [Author]

5-4 The generative technique methodology for generating the plan design

The Mamluk architects had depended on the connection elements as a design tool. The methodology of generating the Madrasa plan design is going in twelve steps as follows:

a- Pre design step : Site analysis

Step 1 : Determine the site boundary.

Step 2 : Determine the qibla direction.

b- Applying the Urban Design Rules (studying visual continuity of the building with its surroundings urban context)

Step 3 : Suggesting the position of the Minerate

Step 4 : Suggesting the position of the Dome

Step 5 : Suggesting the position and composition of the Entrance

c- Applying the Meaning Connection Rules

Step 6 : Suggesting the position and composition of the Sahn and the four Iwans

Step 7 : Suggesting the position and composition of the Mausoleum

d- Step 8: Designing the Function Connection Elements

- 1- Putting the Function Relationship in the building site
- 2- Suggesting the **circulation paths inside the building**
- 3- Suggesting the position, form and composition of the **main connection elements**
- 4- Completing the **design of the connection elements (Corridors)**
- 5- Suggesting the **position of the stairs and the sub-corridors**

e- Completing the design of the other required architectural elements

Step 9 : Completing the **design of the Sahn and Four Iwans**

Step 10 : Completing the **design of the Entrance**

Step 11 : Completing the **design of the Mausoleum**

Step 12 : Completing the **design of the attached architectural elements.**

f- The final design of the building

6- The Applied Study

The most concern for this research understands how Madrasa buildings may have been designed in the first place by the aid of systematic technique. In this paper, a systematic method of design for the derivation of the plans of Madrasa buildings in Mamluk architecture is presented. The method is constructed using a corpus of eleven Mamluk madrasas that were built in Egypt, Syria, and

Palestine during the Mamluk period..

6-1 Applied study limitation

There are many limitation affect the applied study, they are as follows:

- Building drawing analyzed to highlight the two-dimensional logic which governs the design of the plan.
- This generative technique is applied in eleven madrasa buildings. The eleven buildings that have been chosen are not “exceptional” in

many ways. They have been selected according to two conditions: they were built in the Mamluk eras, and they were Madrasas or complex buildings with the Madrasa as their main component.

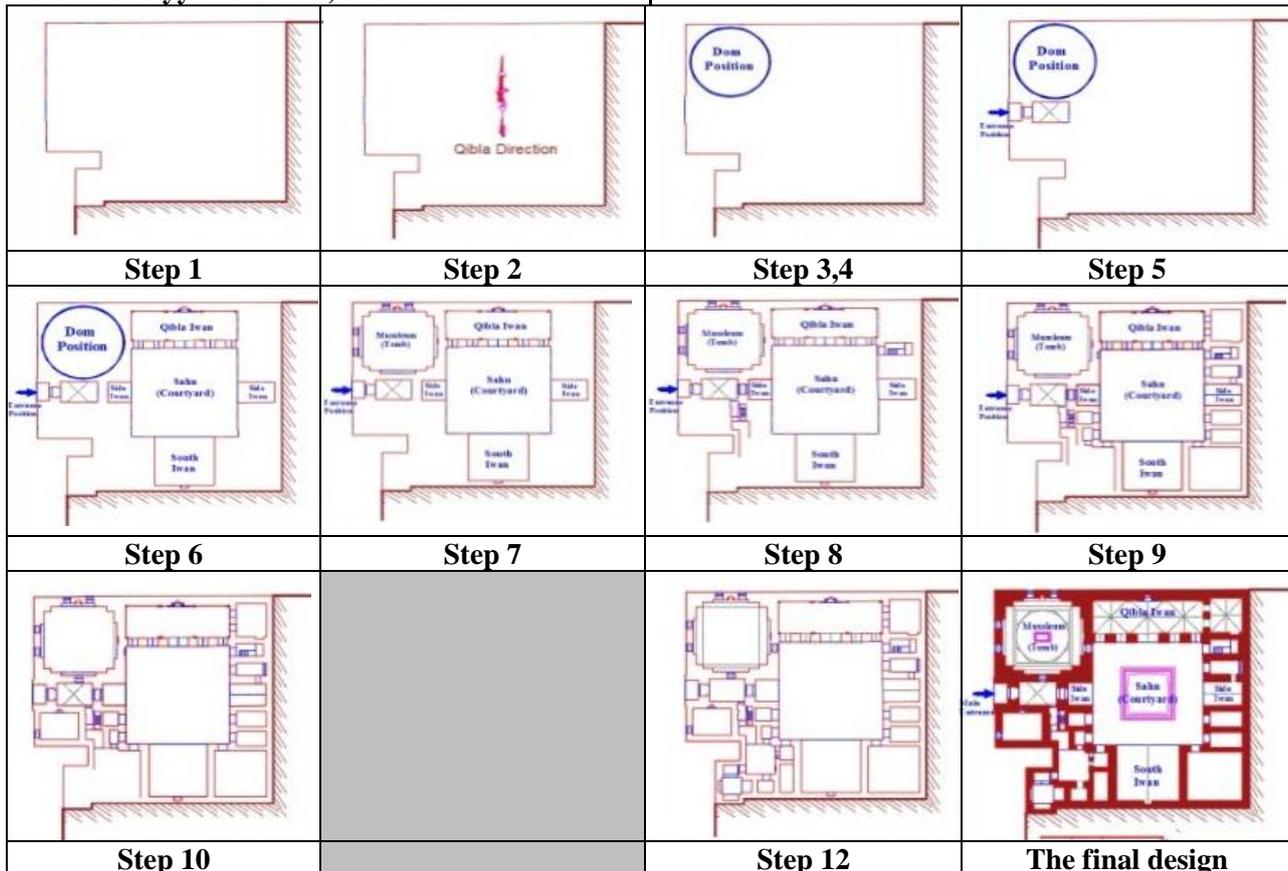
6-2 Case-study buildings

The research applied the generative technique methodology for generating the plan design in eleven case study buildings as follows:

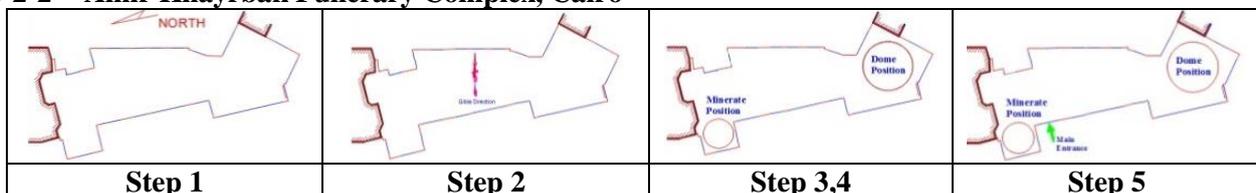
Location	Case-study	Date
Damascus	1- Adiliyya Madrasa	1215/611 AH
Baghdad	2- Mirjaniyya Madrasa	1227-34/625-631 AH
Aleppo	3- Kamaliyya al-Adimiya Madrasa	1241-1251/639-649 AH
Cairo	4- Complex of Sultan Qala'un Funerary	1284-1285/683 AH
	5- Complex of Amir Sarghitmish	1356/756-757 AH
	6- Complex of Sultan Hasan	1356-1362/757-764 AH
	7- Complex of Amir Iljay al-Yusufi	1372/773-774 AH
	8- Complex of Sultan al-Ashraf Barsbay	1432-1433/836 AH
	9- Complex of Sultan Qaytbay (at Northern Cemetery)	1472-1474/876-879 AH
Al-Qudss	10- Complex of Amir Khayrbak	1502-20/907-26 AH
	11- Madrasa of Tashtamur al-'Ala'i	1382-1383/784 AH

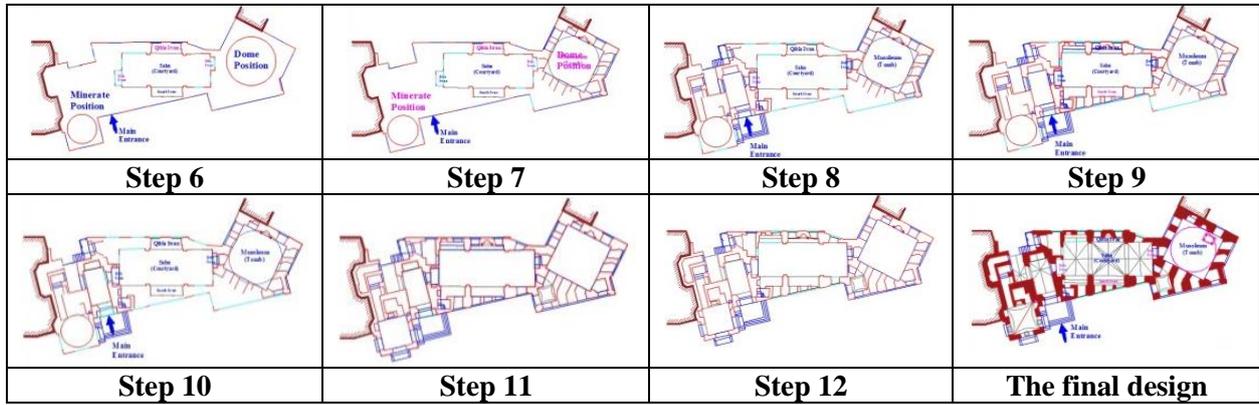
Table (1) Case-study buildings and its distribution in Islamic world

6-2-1 Adiliyya Madrasa, Damascus

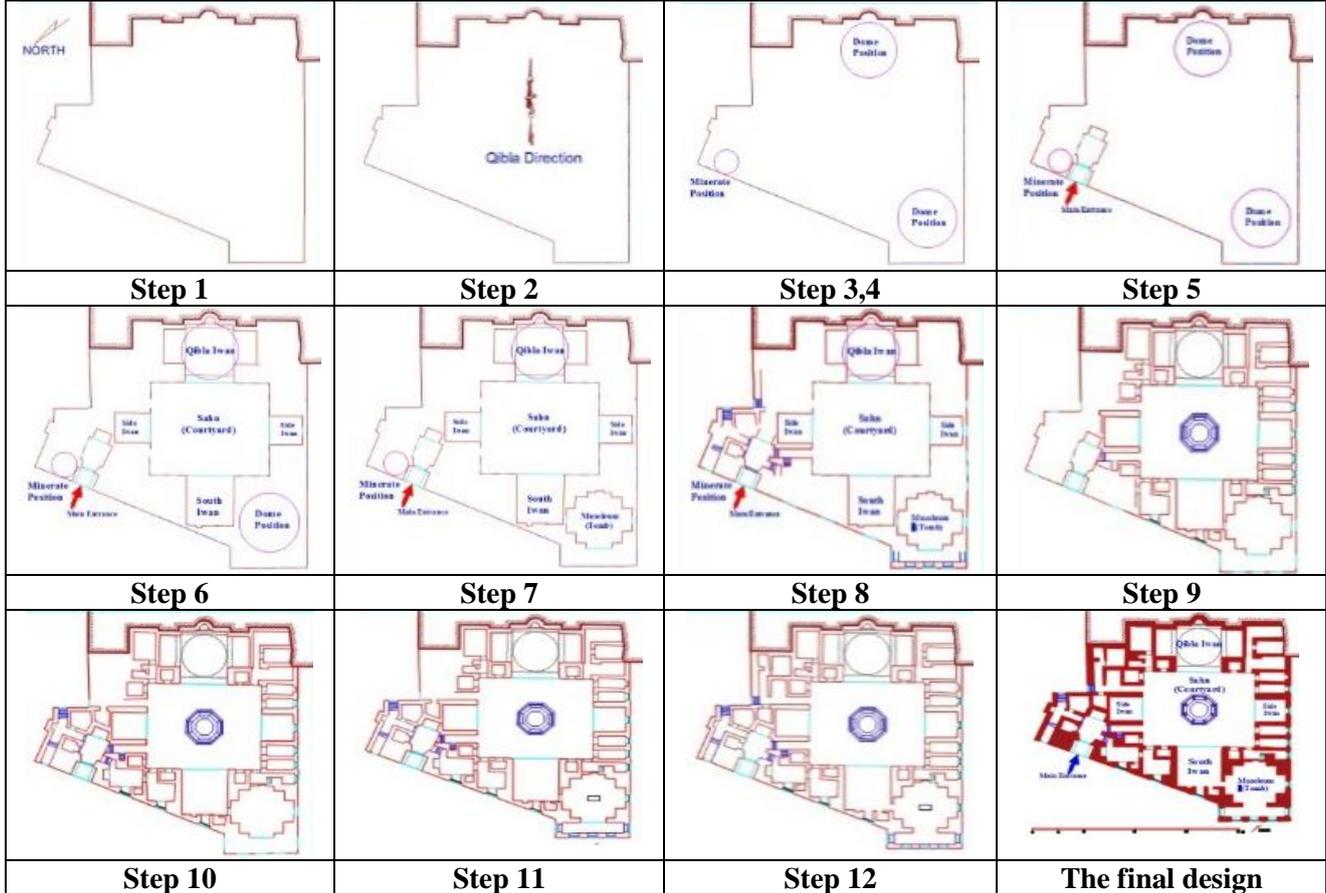


6-2-2 Amir Khayrbak Funerary Complex, Cairo

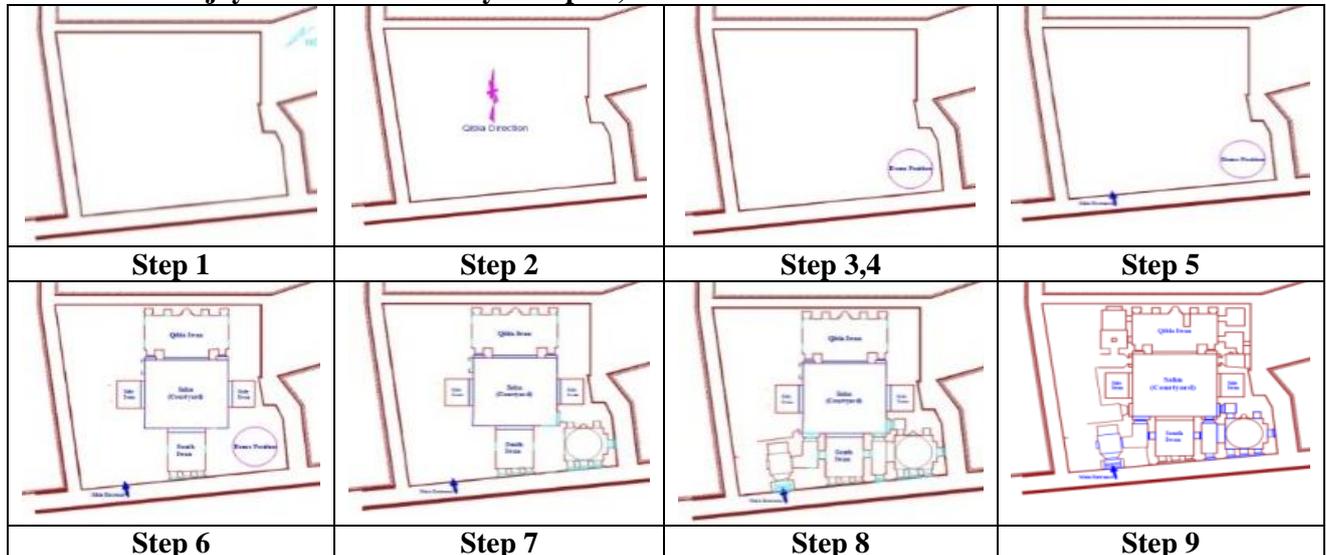


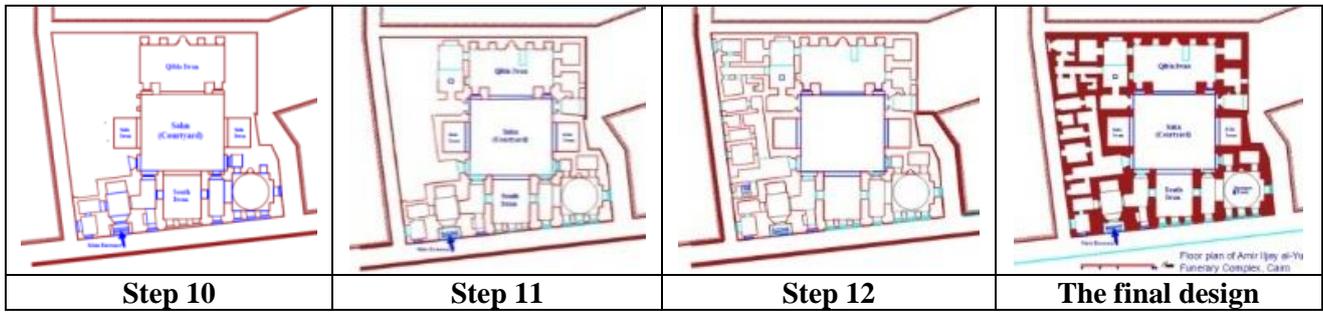


6-2-3 Amir Sarghitmish Funerary Complex, Cairo.

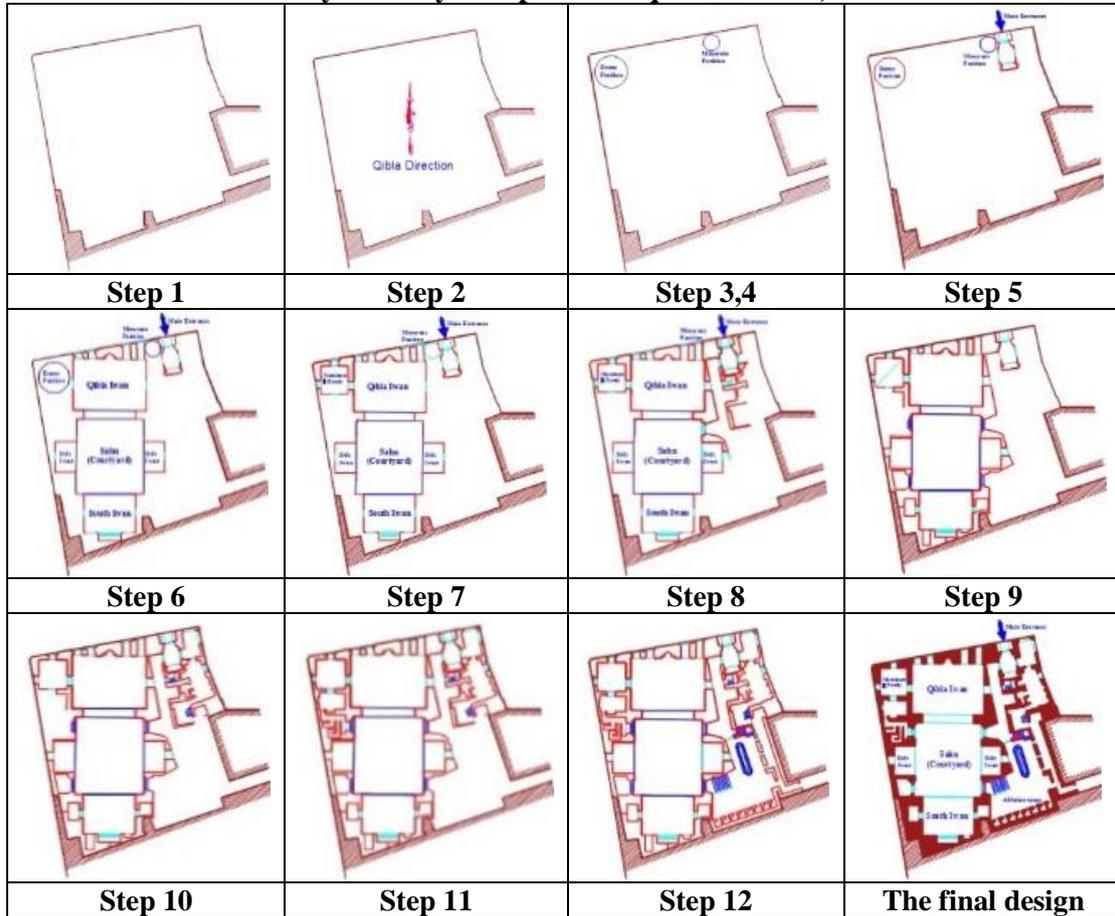


6-2-4 Amir Ijay al-Yusufi Funerary Complex, Cairo

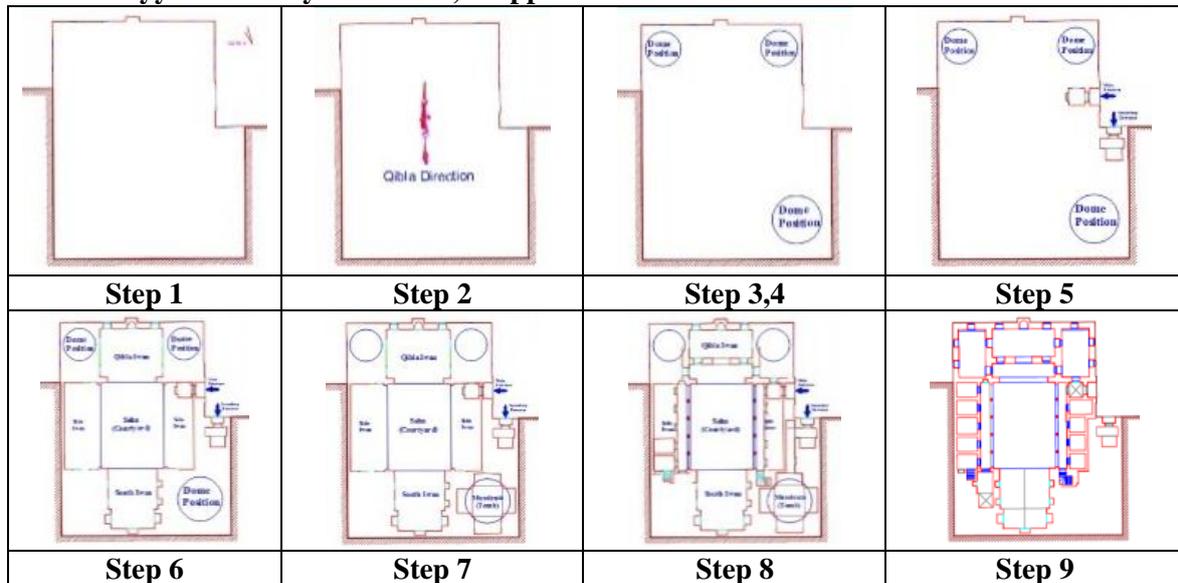


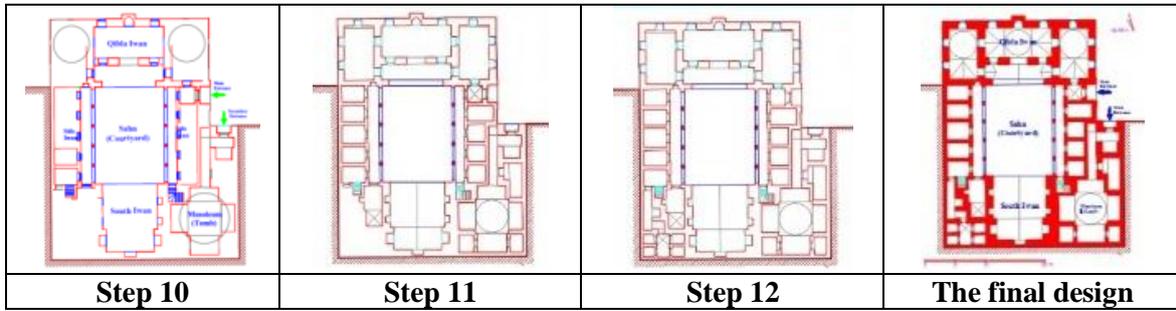


6-2-5 Sultan al-Ashraf Barsbay Funeray Complex at Suq al-Nahhasin, Cairo

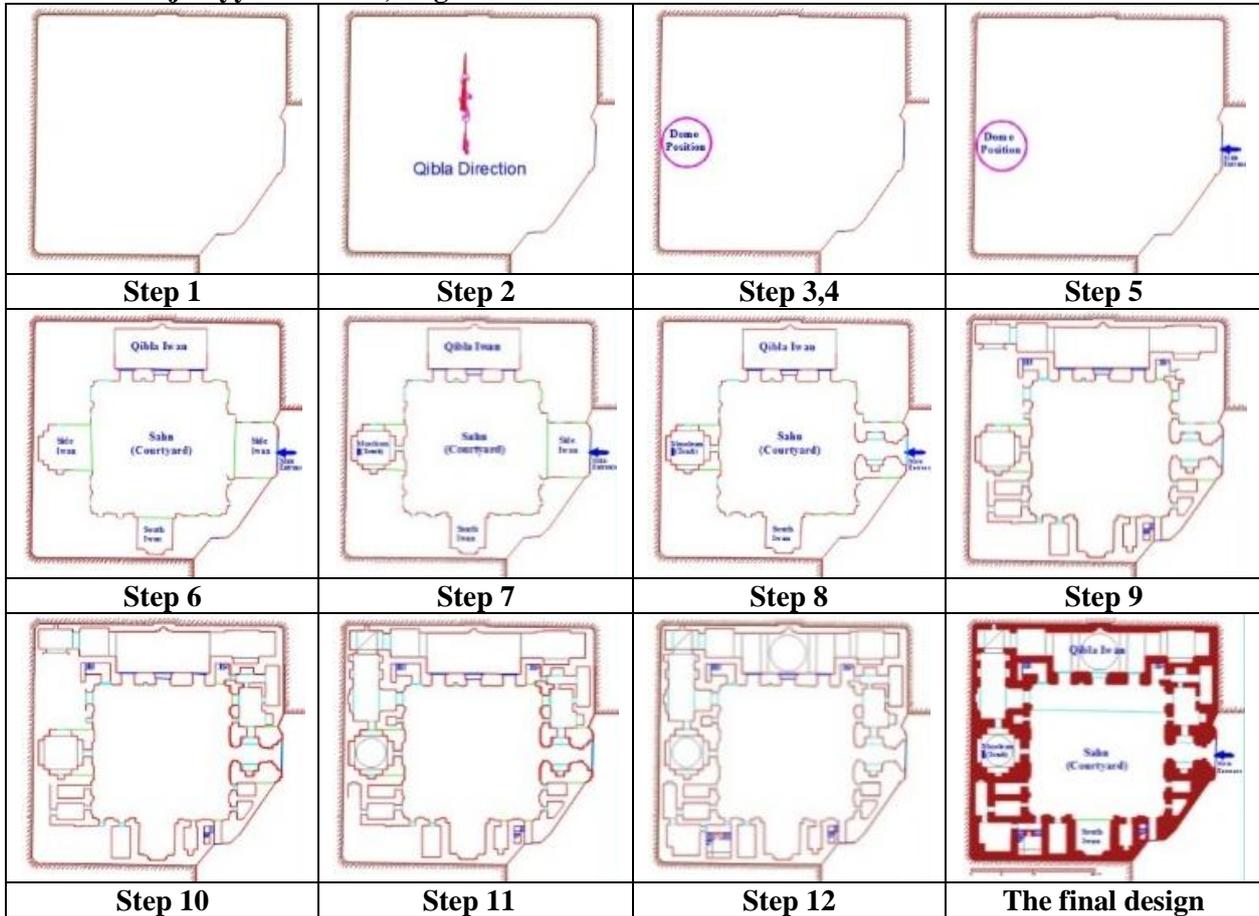


6-2-6 Kamaliyya al-Adimiya Madrasa, Aleppo

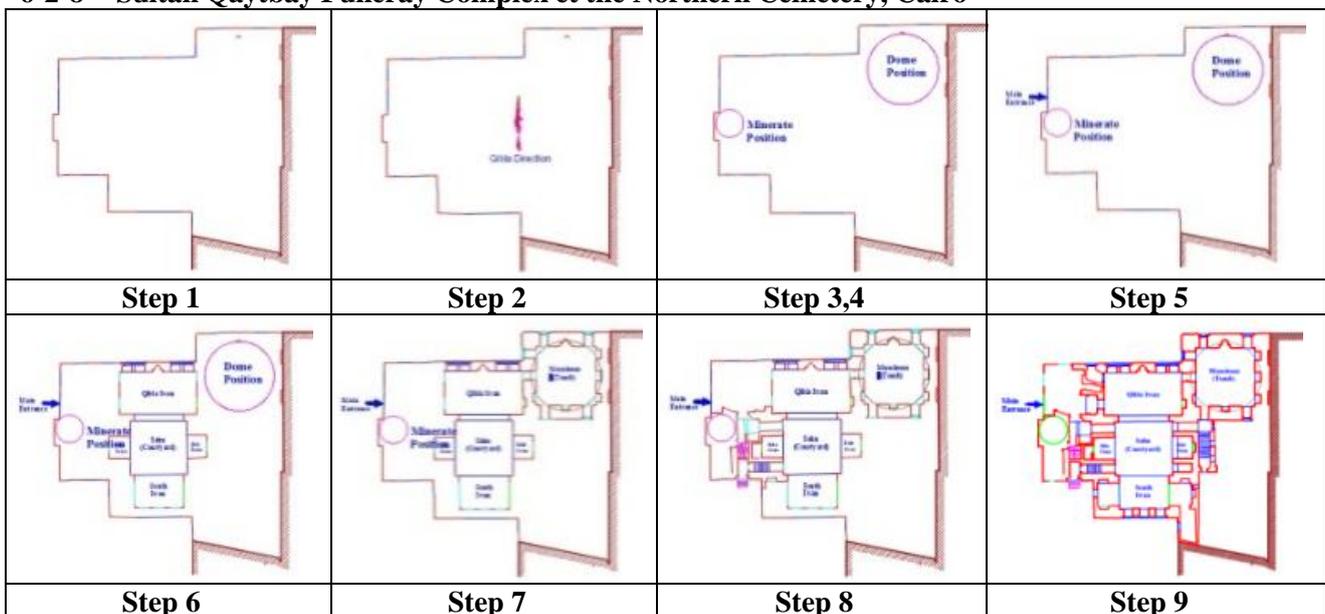


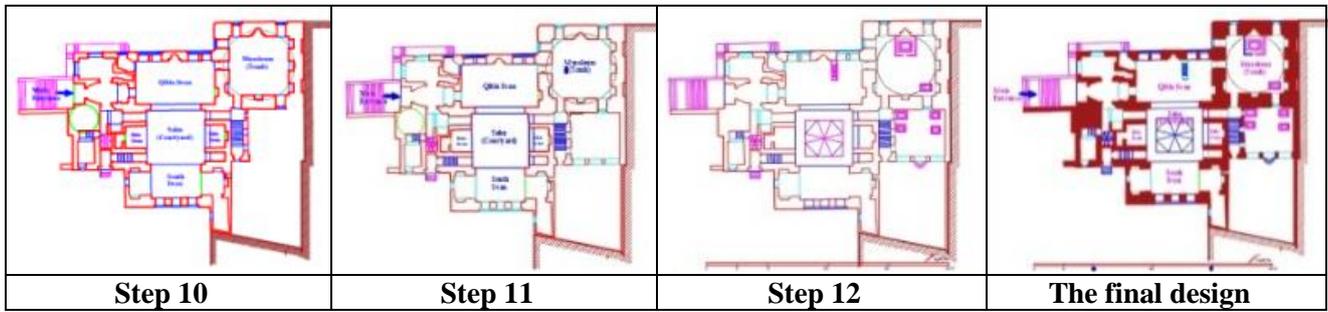


6-2-7 Al Mirjaniyya Madrasa, Baghdad



6-2-8 Sultan Qaytbay Funerary Complex et the Northern Cemetery, Cairo

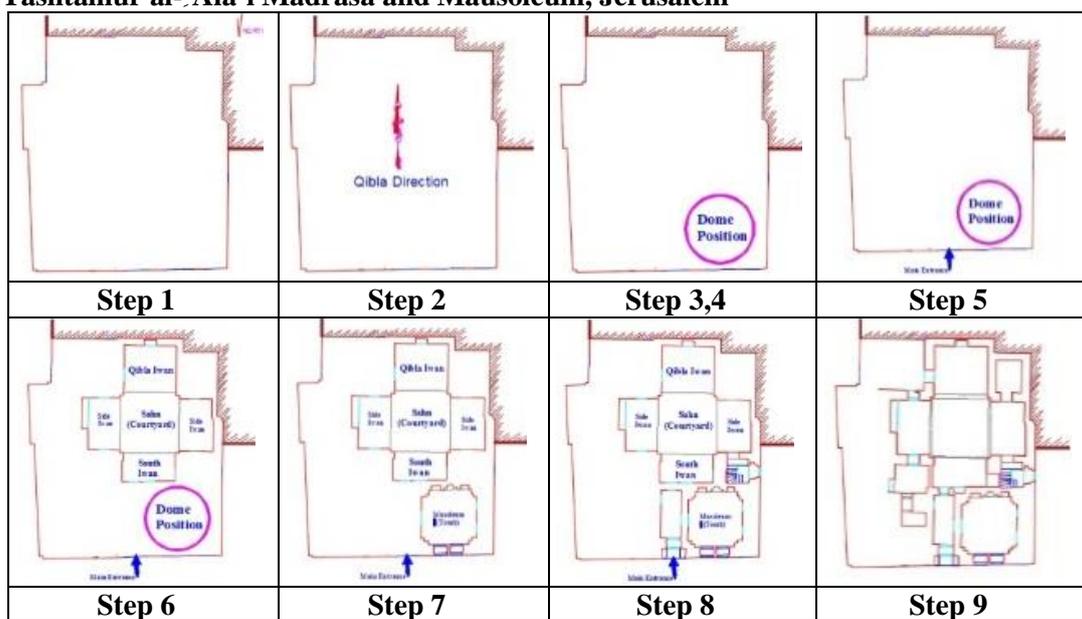


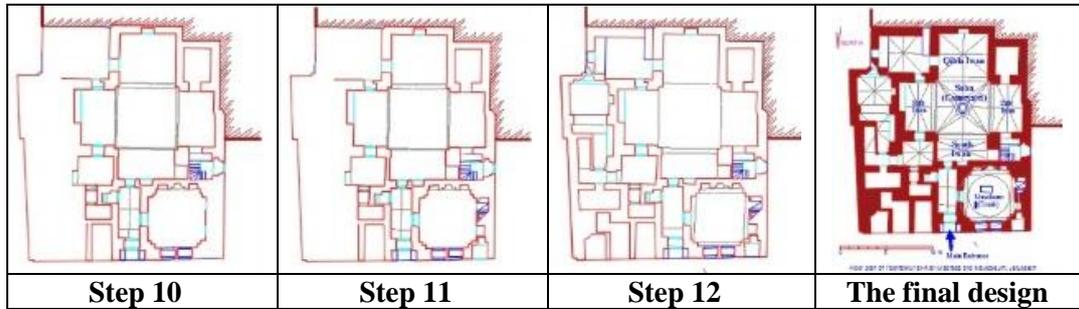


6-2-9 Sultan Qala'un Funerary Complex, Cairo



6-2-10 Tashtamur al-'Ala'i Madrasa and Mausoleum, Jerusalem





7- Conclusion, Results and Recommendations

Although Islamic architecture has undergone several studies over different periods, a majority of mainstream researchers still omit it from their developmental theories on architectural designs and a few give a detailed and comprehensive insight into the architecture of connections in the design of Madasa buildings. This research tries to demonstrate the inherent design technique controlling the design of Madrasa building and explain the role of connection elements in the design process of Madrasa buildings as quickly available reference points for the guideline system of design. The generative design technique introduced in this research seek to bridge the gap between culturally and historically specific forms and functions of multifunctional buildings and the needs of contemporary Islamic societies,

The suggested generative design technique contains a set of design guidelines and principles, it can be understood as a series of architectural grammar that I derived from my study of Islamic architectural history. These design principles enable designers to develop a stylistic and continuity with the past. The generative technique of building design by connection elements in Mamluk architecture had come on five main steps as follows: the first step is pre design step (Design in Context) in which the designer begins with site analysis to reach a unity in the visual design and avoid any conflict between the building and the surrounding urban context, the result of this step he can determine the position of the visual connection element (entrance, dome and minaret) in the building design, the second step is analyzing, in which the designer concerned with two factors: the mutual relationship between the building and deviation of surrounding streets and The building deviation from the Qibla direction, the third step is designing the architectural connection elements: In this step the designer determines two important things: the relationships between the different functions inside the building and the users' circulations diagram. As a result of this step the designer can determine the primary position, form and composition of the different connection elements inside the building, such as corridors and stairs, the fourth step is Applying, in this step the

designer applying the design rules of the connection elements (visual connection rules, function connection rule, meaning connection rules), and finally the fifth step in which he completing the building design, through placing the attached architectural spaces, as a result the designer can generate the final design of the building

The research had reached three main results:

- The information that is produced in this research forms a historical background helps in the process of re-designing or reservation of the Mamluk buildings in the modern society.
- The analysis of historical buildings in Mamluk eras is an alternative tool for understanding the role of connection elements in Madrasa building design and emphasize that these connection elements were not designed arbitrary but further researches must do in order to reveal the design code or the design rules which control the relationship between these elements in the design in Mamluk eras.
- The obtained design technique can be regarded as a doctrine that can be used by contemporary architects as a general model in designing with a consideration of the architecture of connections design criteria and the quality of the traditional Mamluk architecture.

I have often formed in my mind ideas of Madrasa buildings that have given me a wonderful delight, yet when I work them out into design steps and procedures I discover that in the parts which please me most there are hidden order which must be presented. On a second examination of the design, in translating into design criteria I am struck by my inadequacy. Finally, when I have turned my design into a function model and re-examined its elements, I find that I am move according to systematic methodology of design.

The research recommended with that, as final note, traditional Mamluk buildings have to be critically analyzed not only by city planners, architects and landscape architects, but also by urban sociologist and economists, to provide clues for the designers who are about to provide eco-geo, and sustainable urban environments.

REFERENCES:

- 1- [Gaber, 2011] Gaber, A. A. *The methodology of geometric order in the design of traditional*

- Islamic buildings*, PhD, Karlsruhe Institute of Technology, Germany, 2011.
- 2- [Maghbali, 2014] Maghbali A, Rahmati S, *Symbolism in religious art and its effect on the architecture of mosques in Seljuk era*, the proceedings of the first international congress of new horizons in architecture and urban planning. Tarbiat-Modares University, Tehran, 2014.
 - 3- [Behrens-Abouseif, 2007] Behrens-Abouseif, D. *Cairo of the Mamluks: A history of architecture and its culture*, The American University in Cairo Press, Cairo, Egypt. 2007.
 - 4- [Balkhari, 2005] Balkhari Ghahi M, *The logic of art and beauty*, Tehran: the center of Islamic culture publications, 2005.
 - 5- [Paret, 1958] PARET, R. *Symbolik des Islam*. Stuttgart. 1958
 - 6- [VERNOIT, 2000] VERNOIT, S. *Islamic Art and Architecture: An Overview of Scholarship and Collecting, c. 1850-c. 1950*, in Vernoit, ed., *Discovering Islamic art: scholars, collectors and collections 1850-1950*. London: I. B. Tauris. 2000
 - 7- [Mitias, 2018] Mitias M. H., and Jasmi A. *FORM AND FUNCTION IN THE CONGREGATIONAL MOSQUE*, *Estetika: The Central European Journal of Aesthetics*, LV/XI, 2018, No. 1, 25–44
 - 8- [Thackston, 1989] Thackston, W. M. *A Century of Princess: Sources on Timurid History and Art*. Cambridge (Ma), 1989.
 - 9- [Gabr, 1992] Aly Hatem Gabr, *The Influence of Traditional Muslim Beliefs on Medieval Religious Architecture*, Phd, University of Edinburg, Department of Architecture Edinburg, 1992
 - 10- [Wall, 1990] Walls, A. G. (1990). *Geometry and architecture in islamic jerusalem: A Study of the ashrafiyya*, Scorpion Publishing LTD, England.
 - 11- [(OICC), 1992] Organization of Islamic Capitals and Cities (OICC), *Principles of Architectural design and Urban Planning during different Islamic eras*, Centre for Planning and Architectural Studies (CPAS) and Centre for Revival of Islamic Architectural Heritage (CRIAHA), Jeddah, 1992
 - 12- [Petersen, 1999] Andrew Petersen, *Dictionary of Islamic Architecture*, Routledge, London, 1999.
 - 13- [Grabar, 1984] Olega Grabar, *The Expanding Metropolis Coping with the Urban Growth of Cairo : The Meaning of History in Cairo*, Proceedings in Seminar Nine in the Series: Architectural transformations in the Islamic world), The Aga Khan Award for Architecture, Singapore: Concept Media, Ahmet Evin (ed), Cairo, Egypt, 1984.
 - 14- [Grabar, 1993] Grabar, O. (1993). Symbols and Signs in Islamic Architecture, Renata Holod, Darl Rastorfer (Ed), *Architecture in Continuity: Building in the Islamic World Today*, New York, 25-32.
 - 15- [Malhis, 2015] Malhis, S., *Narratives in Mamluk architecture: Spatial and perceptual analyses of the madrassas and their mausoleums*. *Frontiers of Architectural Research* (2015), <http://dx.doi.org/10.1016/j.foar.2015.11.002>
 - 16- [Al-Harithy, 2001] Howayda Al-Harithy, *The Concept of Space in Mamluk Architecture*, Muqarnas XVIII: An Annual on Islamic Art and Architecture. Gülru Necipoglu (ed.). Leiden: E.J. Brill, 2001
 - 17- [Tantawy, 2002] Shams Al-Din Mahmoud Tantawy, *Conceptualizing Mamluk Architectural Heritage For a Contemporary Society: Issues of Design within a Preservation and Conservation Paradigm*, Phd, Cairo University, Architecture Department, Cairo, 2002
 - 18- [Abu Sirryeh, 2019] Abu Sirryeh S., *Sustainability Principles in Traditional Islamic Architecture*, 2018
<https://www.ecomena.org/sustainability-islamic-architecture/>
 - 19- [Attia, 2009] Shady Attia (22–24 June 2009). *Designing the Malqaf for summer cooling in low-rise housing, an experimental study*. 26th Conference on Passive and Low Energy Architecture (PLEA2009).
 - 20- [Elkhateeb, 2012] Elkhateeb A. A., *Domes in the Islamic Architecture of Cairo City: A Mathematical Approach*, *Nexus Netw J – Vol.14, No. 1, 2012*
 - 21- [Raymond, 1994] Raymond, A. “*Islamic City: Orientalist Myths and Recent Views*,” *British Journal of Middle Eastern Studies*, 21, (1), pages: 3-18, 1994.
 - 22- [Moubarak, 2020] Moubarak L., *The Egyptian City Centres in The Islamic Era: Image Analysis, Evolution and Contemporary Reflection*, *Journal of Engineering Sciences, Assiut University, Faculty of Engineering*, Vol. 48, No. 3, 2020.
 - 23- [Rashid, 2020] Rashid, M. (2020). *Islamic Architecture: An Architecture of the Ephemeral*. Downloaded from: <http://hdl.handle.net/1808/30156>
 - 24- [Dluhosch, 1974] Dluhosch, Eric. “*Flexibility/Variability and Programming*.” *Industrialization Forum* 5, p. 39-46, 1974.
 - 25- [Archnet]

- <https://archnet.org/collections/843/publications/1369>
- 26- Mamluk Minarets in Modern Egypt: Tracing Restoration Decisions and Interventions
- <https://journals.openedition.org/anis/2195>
- 27- [wikipedia] Articulation (architecture)

- [https://en.wikipedia.org/wiki/Articulation_\(architecture\)](https://en.wikipedia.org/wiki/Articulation_(architecture))
- 28- [rudi] CONNECTIONS IN ARCHITECTURE AND URBAN DESIGN
- <http://www.rudi.net/books/4701>

