

THE EVOLUTION OF MUQARNAS IN IRAN FROM PRE-SELJUK TO
ILKHANID PERIOD

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Architecture)

Faculty of Built Environment
Universiti Teknologi Malaysia

JUNE 2014

*To my beloved family members;
my adorable parents, my lovely wife,
and
to the little sweet member of my family, Ava.*

ACKNOWLEDGEMENT

I appreciate the moment to express my sincere gratitude to my precious supervisors, Associated Professor Dr. Syed Ahmad Iskandar bin Syed Ariffin, and Associated Professor Dr. Gholamhossein Memarian of IUST, and my distinguished teacher of Islamic art, Maestro Aliasghar Sha'rbaf, for their kind encouragements and guidance, critics and friendship during these years. I am thankful to Professor Dr. Mohd Hamdan and to his lovely family who made me feel supported and welcome all these years that I was far away from my family.

I am very much grateful to my darling wife, Dr. Moones Rahmandoust, for her kind and never-ending motivations and encouragements; without her support and patience, I would not have been able to dedicate my time to my research and to make my path toward greater success.

I also admire and thank my respected parents, Mr. Abbas Kazempourfard and Ms. Malak Ghaderi; my distinguished parents in-law, Dr. Mostafa Rahmandoust and Ms. Azar Rezaee; I owe all the nice and valuable moments of my life to them. Further, I appreciate my father as my first and best teacher of traditional art, without whom, I would not have the chance to understand the beauty of Islamic art and architecture, to this extent.

Many of my friends are also worthy to be very much appreciated here: Dr. Seyed Javad Asadpour, Dr. Reza Hashemi, Hadi Safaeipour, Ala Amirfazli, Dr. Feryal RezaeeMood, Shima Taslim, Nima Norouzi, Dr. Mohammad Ghomeishi, Dr. Hesam Sotoudeh, Nima Moinzadeh, Dr Hassan Chizari, Dr Alireza Daneshpour and Hadi Ebadi for their friendly participation in our scientific discussions and sharing their views and tips to achieve better and more reliable results. I'm grateful to Rokhsareh Mobarhan, Mojib Majidi, Fahimeh Malekinezhad, Morteza Firouzi and Masoumeh Zibarzani as well, for their kind assistance and friendly help at various occasions.

ABSTRACT

Muqarnas has always been one of the most complex decorative elements of world's monumental architecture. In *muqarnas*, niche-like components are combined together and arranged in successive tiers to produce a three-dimensional geometric shape, enclosing and embellishing features such as ceiling, soffit, portal, and vault. This unique structure has been intensely studied from various aspects by many scholars. Nevertheless, there is still lack of clarification about the structure's origin and path of evolution. There are some theories indicating that the structure is originated from squinches in Iran, but no further explanation is provided to fill the huge gap between the two, i.e. *muqarnas* and squinch, and to clarify the quality of the gradual development. This study assumes that the missing link between *muqarnas* and squinch should be sought in another undefined form in traditional architecture of Iran, named *patkaneh*. In this research, the main effort is to investigate the possibility of differentiating this ornament from *muqarnas* and to introduce it as a different structure, which is the missing link between squinch and *muqarnas*. This thesis employs a qualitative approach that strives to demonstrate the steps of gradual deformation of *muqarnas* from squinch by defining the characteristics of the linking ornament, using an inductive approach. For that, 20 critical samples of *muqarnas* and pseudo-*muqarnas* were selected out of a collection of 100 structures, by considering three main perspectives, i.e. chronology, form and structure, and construction techniques, with specific attention to the structure's constituent elements and number of tiers as an indicator of the ornaments complexity. The differences and similarities identified among the selected samples lead to demonstrating the structure's path of evolution. The results show there is another type (*patkaneh*) of ornamental structures with different characteristics in comparison with *muqarnas*. Therefore, this study contributes *patkaneh* as the connecting link between *muqarnas* and squinch, which is misinterpreted in many texts as *muqarnas* and thereafter shall be appropriately referred to none other than *patkaneh*.

ABSTRAK

Muqarnas sememangnya merupakan salah satu elemen dekoratif yang paling kompleks merentasi sejarah senibina monumen dunia. Pada *muqarnas*, komponen ala mihrab digabung dan disusun mengikut lapisan takuk yang berturutan untuk menghasilkan satu bentuk geometri tiga-dimensi, menutupi dan menghiasi elemen seperti siling, sofit, gapura dan kekubah. Struktur unik ini telah dikaji secara mendalam dari pelbagai aspek oleh ramai cendekiawan. Namun penjelasan tentang asal usul struktur dan jejak evolusinya masih tidak jelas. Terdapat beberapa teori yang menunjukkan bahawa struktur ini berasal dari *squinch* di Iran, tetapi tiada keterangan lanjut diberikan untuk mengisi jurang antara *muqarnas* dan *squinch*, dan seterusnya menjelaskan kualiti evolusi perkembangannya. Penyelidikan ini mengandaikan bahawa hubungan yang terpisah antara *muqarnas* dan *squinch* perlu dicari dalam bentuk tidak berdefinisi yang lain dalam senibina tradisional Parsi, disebut *patkaneh*. Dalam penyelidikan ini, usaha utama ialah untuk menyiasat kemungkinan membezakan ornamen ini dari *muqarnas* dan memperkenalkannya sebagai suatu struktur yang berbeza yang merupakan penghubung yang belum pernah diketahui antara *squinch* dan *muqarnas*. Tesis ini merupakan kajian kualitatif yang sedaya usaha mahu mempamerkan langkah-langkah deformasi bertahap *muqarnas* dari *squinch* secara mendefinisikan ciri-ciri ornamen penghubung menggunakan pendekatan induktif. Untuk itu, sebanyak 20 sampel kritikal *muqarnas* dan *pseudo-muqarnas* telah dipilih dari koleksi 100 struktur dengan mempertimbangkan tiga perspektif utama iaitu kronologi, bentuk dan struktur, dan teknik pembinaan, dengan memberikan penumpuan spesifik kepada jujuk-jujuk elemen struktur berkenaan dan lapisan takuk sebagai petunjuk kepada kompleksiti ornamen. Perbezaan dan persamaan struktur dalam kalangan sampel terpilih telah mendorong kepada pembuktian jejak evolusi struktur berkenaan. Keputusan penyelidikan ini membuktikan bahawa terdapat satu jenis lain (*patkaneh*) dari struktur berornamen dengan ciri-ciri yang berbeza berbanding *muqarnas*. Sehubungan dengan itu, penyelidikan ini menyumbang *patkaneh* sebagai struktur ornamen penghubung diantara *muqarnas* dan *squinch*, yang telah disalahtafsir dalam banyak kajian dan penulisan sebagai *muqarnas*, dan berikutan dengan itu ia sepatutnya hanya dirujuk sebagai *patkaneh*.

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LIST OF ABBREVIATIONS

| | | |
|------|---|------------------------------|
| C.E. | – | Current Era |
| B.C. | – | Before Christ |
| A.H. | – | After Hijra |
| ca. | – | circa, means about |
| i.e. | – | That is |
| e.g. | – | For example |
| 2DPP | – | Two-Dimensional Pattern Plan |
| ETP | – | Edge to Point |
| ETE | – | Edge to Edge |
| PTE | – | Point to Edge |
| Msq. | – | Mosque |

LIST OF APPENDICES

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GLOSSARY

- Muqarnas*** – The most advanced ornament in Islamic architecture invented in early 14th century. This structure is purely decorative, adding dead load to the building. The constituent elements of *muqarnas* are confined to the eight basic elements, namely *shamseh*, *taseh*, *toranj*, *shaparak*, *parak*, *tee*, *espar* and *takht*.
- Patkaneh*** – A set of niche-like components arranged in successive tiers in a definite geometrical regime, in order to cover vaults or ceilings. *Patkaneh* is a load-bearing transition structure, dating back to the 10th century. The structure consists of two main parts, the ribs that provide the structural role for the ornament, and the *tasehs*, built between these ribs, in two to maximum five successive projecting tiers. Plumb *paraks* and *shaparaks* are the intermediate elements observed in *patkanehs*, although exceptional samples had been recorded with three-dimensional *paraks* or *shaparaks* in late 12th century.
- Squinch*** – It is the oldest known transition technique, which can be considered a single *taseh*. It consists of two load-bearing concave vault-sections intersecting each other in a line at right angle.
- Shamseh*** – The central medallion, a three dimensional star.
- Taseh*** – A symmetric edge to point *muqarnas* component consisting of one to eight concaved triangular segments. Though, a single-segment *taseh* may be also two-dimensional.
- Shaparak*** – A flexible point to edge intermediate element, consisting of two attached concave triangles, capable of covering various angles efficiently.

- Parak*** – A point to edge intermediate element, consisting of a single concave triangle.
- Toranj*** – A tetrahedral element, with axial symmetry, which may be compressed or elongated based on its position in the ornament with respect to its neighbor elements.
- Tee*** – An edge to edge plumb intermediate element that is in fact a long rectangle which is normally attached to a *takht* element on its lower edge and has two flanking *paraks* as its lateral neighbours, making the whole combination similar to letter T.
- Espar*** – *Espar* is an edge to edge plumb element created in 12th century, with the lower edge bigger than the top one. The edges are connected to each other by means of two curved lines. The word is the Persian equivalent of “entablature” as an architectural term. *Espar* can be observed in the first few tiers of *muqarnas* on the walls and in the space between two *shaparaks*.
- Takht*** – *Takht* elements are the only horizontal elements which are specific to *muqarnas* and cannot be seen in any pseudo-*muqarnas* structures, before 14th century. They may have regular or irregular geometric shapes. Regular *takhts* are star shaped flat elements, like three-, four-, five-, six-, seven- and eight-pointed stars and other shapes are defined as irregular *takhts*. The existence of any *takht* element in an ornament shows that the ornament is undoubtedly a *muqarnas*.
- Tier*** – Each of the successive levels in which the constituent elements of *muqarnas* and pseudo-*muqarnas* ornament are arranged.

CHAPTER 1

INTRODUCTION

1.1 Chapter Opening

Muqarnas is one of the most complex ornaments of Islamic architecture also used in many non-Islamic buildings, such as cathedrals and palaces. The geometrical complexity of this structure has attracted the attention of many scholars and researchers in many famous and high ranking universities of the world.

Muqarnas is sometimes termed as a *stalactite* or *honeycomb* as well. Figure 1.1 shows a *muqarnas* dome built by the author in 2005, in Varamin, Iran. The pattern of this *muqarnas* veneer of designed by Maestro Sha'rbaf, who is a world famous traditional mason and designer. In her book, Necipoglu refers to him as the only reference for all the issues related to traditional techniques of designing and constructing *muqarnas* in Iran (Necipoglu, 1995). The author is proud to be mentored by Maestro Sha'rbaf for more than 10 years and to learn from him many subtle details and characteristics of *muqarnas* through working with him and constructing many *muqarnas* samples under his supervision in Iran.

As a result of the existence of *shamseh*, i.e. the central sunburst medallion at the apex of the work, as well as the star-shaped *takht* elements, dispersed over other tiers of the ornament in a radial scheme, the appearance of the structure induces the pattern of the sky in the eyes of the observer, in a way that since 12th century, many Persian poets used the term *muqarnas* in their poems as a metaphor for sky.

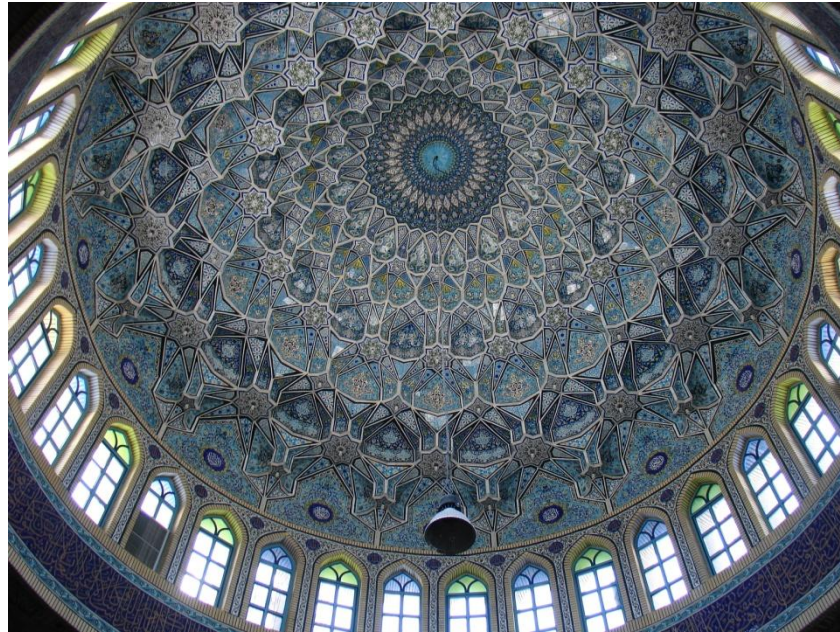


Figure 1.1 *Muqarnas* dome designed and built by author, Jame' of Varamin (Source: Author).

In spite of the great amount of research carried out about this art, there are debates about the chronological or geographical origins of it. But what is for certain is that by the end of the 12th century, *muqarnas* was not only widely used all over the Muslim world, but it was in many regions mixed and developed by local traditional ornaments as well. However, some scholars believe that *muqarnas* originated from either Iran or Syria in the late 8th and early 9th centuries and some others trace its roots in northern parts of Africa or Baghdad in the 11th century (Al-Asad, 1995).

Among the available studies, there is a reliable theory by Michel Écochard introducing *squinch* as the functional origin of *muqarnas* in Iran, in the 10th century,

but he does not explain the path of this gradual change (Écochard, 1977). Stierlin also believes that the origin of *muqarnas* goes back to the squinch. He explains his theory by mentioning that *muqarnas* structures are in fact several little squinches (Stierlin, 1976). Later on, Harb tried to explain the connection between *muqarnas* and squinch by means of Roman pendentives (Harb, 1978). To the author's best knowledge, these are the only available sources trying to explain how Iranian *muqarnas* structure was developed into its current state (Harb, 1978).

Practically, today's geometrically complex *muqarnas* originated from a simpler pseudo-*muqarnas* structure named *patkaneh* which should be defined and explained in detail in order to enlighten the evolution of *muqarnas* through passage of time, in terms of changes in its form and structure, as well as the applied construction techniques. *Patkaneh* is a set of niche-like components arranged in successive tiers in a definite geometrical regime, in order to cover vaults or ceilings. Hence, introducing *patkaneh* more specifically as the practical origin of *muqarnas* and as the missing link between squinch and *muqarnas* is one of the goals of this research.

By studying the earlier samples of *muqarnas*, one can assert that the structure was completely structural at the beginning, playing the role of a smooth transition from square base of the wall to the circular base of domes, vaults and ceilings, but later it was transformed into a purely decorative structure leading to today's ultimate form of *muqarnas*.

1.2 Evolution of *muqarnas*

Although in traditional Islamic architecture, there are usually divine concepts attributed to the appearance of forms and structures, they are simultaneously in

complete conformity with construction rules. In other words, the architects and masons were capable of explaining the soaring ideas through the knowledge of structure and material.

There seems to be a general practice in Islamic architecture, that is, forms and figures of elements, which are constructed for structural purposes in a building, are gradually transformed into non-load-bearing decorative elements. Similar process of transformation may be observed in other architectural schools, but what makes Islamic architecture different is that the architects and masons were mixing the new elements with an Islamic theme (Edwards & Edwards, 1999). Another specific characterization of Islamic architecture is that it makes the observer confused of whether the specific form was supposed to be structural or decorative. Though, there are many samples in which a complete combination of both purposes can be seen.

Muqarnas is a unique example of a form in Islamic architecture that possesses the path of evolution and maturation from a pure structural role to a purely decorative one. This research intends to demonstrate the path of development of *muqarnas* in light of three factors, hence time, form and structure, and construction technique, as the factors that played the key role in the process of this reformation, based on the existing samples in Iran.

1.2.1 Chronology

After Holy Prophet of Islam passed away in 632 C.E., Islamic world was governed by Umayyad (661–750) and Abbasid (750–1258), expanding to Near East, Middle East, North Africa and a great part of Spain. In the 9th century, the capital of the Caliphate at Baghdad lost control over the eastern provinces and from early 11th

century Seljuks established an independent Islamic sultanate expanding from Greater Iran to Near East. At that time, Egypt became the capital of the Caliphate of Fatimids (969–1171). Figure 1.2 (a) shows the governing borders of Seljuk dynasty.

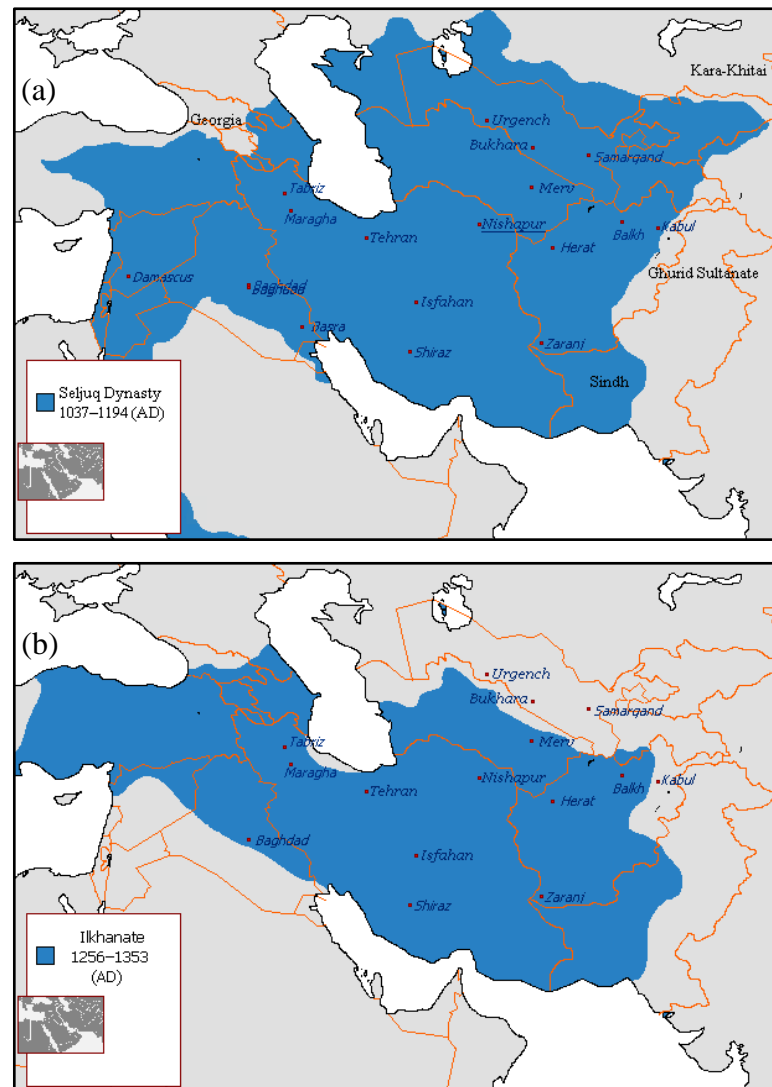


Figure 1.2 Map of Iran during (a) Seljuk and (b) Ilkhanid periods (Source: Wikipedia).

Starting with the 13th century, after frequent invasions by the Mongols, Islamic government of the Middle East lost its power, and in 1256, Baghdad, the capital, was completely overran by the Mongols and the Ilkhanid dynasty was established. In 1295, the Ilkhanids embraced Islam and devoted their efforts towards

expanding the Islamic architecture in Iran then after, by building mosques and schools and mausoleums. Figure 1.2(b) illustrates the borders of Iran during Ilkhanid dynasty. Later on, Timurids (1370–1506) conquered the eastern parts of their territories and after them Safavids (1502–1736) achieved the control over the East and the Ottomans (1300–1924) over the Western parts (Edwards & Edwards, 1999).

Based on the explanations above, the main focus of the current study about discovering the evolutionary path of *muqarnas* in Iran, includes mainly the Seljuk (1038–1194) and Ilkhanid (1256–1353) dynasties, although examples from periods, before and after the mentioned dynasties, were also considered, when necessary (Wilber, 1955; Schroeder, 1977).

1.2.2 Form and Structure

In order to discover the progress of the evolution from squinch to *patkaneh* and *muqarnas*, existing samples of all mentioned structures were recorded and analyzed in both form and structural aspects. By *form*, the appearance of the elements is intended, i.e. whatever the observer learns by looking at the *muqarnas*, including the finishing material, the number of tiers or rows, the size, and colour of elements of *muqarnas*. By *structure*, the material used to build the base of the studied ornament is targeted, as well as the geometrical shape of the constituent elements. In fact, there are many examples in which the material used for *muqarnas* is different from that of a building, e.g. masonry buildings with stucco *muqarnas*. Therefore, it is necessary to consider the structure of *muqarnas*. The two–and three–dimensional pattern of the *muqarnas* samples were also created and analyzed to obtain more knowledge about the structure of the constituent elements of each sample.

Hence, with the purpose of achieving a substantial database for discovering the evolution of *muqarnas*, 100 samples were recorded on-site. Photographs were taken and measurements done. Furthermore, the two- and three-dimensional plans and patterns were illustrated and gathered for further studies. The form and structure of the constituent elements of the recorded samples were investigated, analysed and compared with each other in detail, to make it possible to differentiate and define the characteristics for each studied sample accurately.

1.2.3 Construction Techniques

Construction technique is another important concept in distinguishing the different types of *muqarnas*. The method and material with which the underlying construction of the *muqarnas* is pursued, the way the mason carried out the *muqarnas* from its plan, and finally if the studied *muqarnas* is a load-bearing structure or if it is merely a decorative element added to the building, are the items that were discussed and concluded in this part of research. There are samples which force us to go beyond its appearance and find out about its nature from what is hidden behind it and how it is attached to the wall or ceiling of the building, i.e. the hidden part of *muqarnas*.

Lack of knowledge among scholars about the traditional methods of drawing *muqarnas* plans and building them by experimental craftsmen and traditional masons has produced a large amount of questions in understanding and interpreting available *muqarnas* patterns and plans. One of the most remarkable distinctions of the current study, with respect to other existing studies, is the author's wide knowledge on the traditional methods of drawing *muqarnas* plans and methods of building it. This rare and useful knowledge is obtained from a family with rich background in traditional architecture, as well as being mentored and having constructed many *muqarnas* structures for many years, under the supervision of world-famous masters of Iranian

traditional architecture, namely, Maestros Sha'rbaf and Maheronnaghsh. This can be considered a privilege as it gives the author a better insight in understanding the phenomena and its complex nature.

1.3 Statement of the Problem

Muqarnas has always been one of the most complex decorative elements of the world's monumental architectures across history, in which niche-like components are combined together and arranged in successive rows to produce a three-dimensional geometrical surface, enclosing a ceiling, soffit, portal, vault, etc. This unique structure has been studied from different aspects by many scholars in many high-ranking universities such as Massachusetts Institute of Technology (MIT), and Harvard University in the United States, Tama Art University of Japan, Heidelberg University of Germany, King Saud University of Saudi Arabia, and Iran University of Science and Technology (IUST) and by many world-famous architecture historians and archaeologists (Necipoglu, 1995; Takahashi, 1973; Harmsen, 2006; Dold-Samplonius, 1996; Memarian, 2012; Yaghan & Hideki, 1995; Yaghan, 2000). Despite, there is still debate about the origin of the structure and about its definition.

There are theories asserting that squinch, which is considered an invention of Iranian architecture, is the predecessor of *muqarnas* (Écochard, 1977; Stierlin, 1976; Harb, 1978). Though, there is no explanation on the quality of gradual evolution. The problem arises from a very important misunderstanding about the definition of this structure and how it is different from other pseudo-*muqarnas* structures.

Muqarnas is in fact an advanced and famous form in Islamic architecture, which is rooted from a simpler unknown form in traditional architecture of Iran,

named *patkaneh*. This structure, which will be clearly introduced in this research, is in fact the missing link between squinch and *muqarnas* that should be introduced to the body of knowledge.

1.4 Research Gap

In spite of the fact that the word *muqarnas* refers to a unique world-known structure, which is considered as the signature ornament of Islamic architecture, depending on the perception of the scholar who tried to define the characteristics of the structure and his available resources, as well as the location of the *muqarnas*, which results in a variety of characteristics and dimensions, vast and diverse interpretations of the phenomenon is available.

Although many researchers devoted their efforts to clarify different aspects of this structure, different concepts out of the same context are introduced and still there is debate about the very basic aspects of *muqarnas*, in terms of concept and basic physical characteristics. Even in Iran, which is known as one of the major candidates as the structure's place of origin, despite the diversity of *muqarnas* types, still little attention is paid to clarifying the concept as well as the physical characteristics of the structure and its different types, in association with its role in a building.

Squiches are introduced in some reliable theories as the functional origin of *muqarnas* in Iran. Though, the huge gap between the two structures has been ignored. Little attention is paid to demonstrating the gradual development of squinch towards *muqarnas*. Lack of clarification on categorization of the concept in association with the characteristics of its components, detracts the scientific understanding of these unique structures.

In other words, to differentiate the concept of *muqarnas* from its other similar structures, it is necessary to distinguish the actual structure from those, which will be referred as pseudo-*muqarnas* structures. This differentiation enables the researcher to explicitly recognize these different structures, which in turn assists in identifying each category based on its particular characteristics. The clarification of characteristics and architectural attributes of different types of the structure would be useful in classifying the achieved findings towards a systematic expansion of the knowledge. This knowledge will help in protecting and codifying these valuable historical ornaments not only by providing better perception of their details but also by making a scientific documentation of them to be transferred to the next generations.

1.5 Research Aim

Based on the explanations above, this investigation strives to clarify the definition of *muqarnas* by demonstrating the evolution of this ornamental structure in Iran, from 10th to 14th century and by seeking the missing link between *muqarnas* and squinch.

1.6 Research Objectives

The stated aim of this research is expected to be achieved through the following objectives:

- (1) To seek the time period in which *muqarnas* structure is fully developed to its optimum form by recording existing *muqarnas* and pseudo-*muqarnas* samples in Iran.
- (2) To investigate the constituent elements of *muqarnas*, with the purpose of developing a minimized but general set of basic constituent elements that could cover all elements of all *muqarnas* structures of all times.
- (3) To clarify the similarities and differences between *muqarnas* and other pseudo-*muqarnas* structures; and finally,
- (4) To define each ornament clearly, i.e. squinch, *patkaneh*, decorative *patkaneh* and *muqarnas*, from three aspects, namely chronology, form and structure, construction techniques.

The abovementioned objectives should be accomplished in a sequential order. In other words, the results from each objective will be used as a tool to achieve the next objective.

1.7 Research Assumptions

Muqarnas is an ornamental structure which is considered to have originated from another simple structure known as squinch. Though, the connecting link between the two completely different structures is unknown. The link is in fact another ornament which is simpler than *muqarnas* but more complex than squinch. The connection, that is assumed to be a structure named *patkaneh*, should have similarities and differences with both limiting cases. *Patkaneh* is made up of several ribs, containing small squinches inside them. This structure which is generally made of the same material as the building is built from bottom to top, in a way that each tier is supported by its lower one, transferring its weight through that or the hidden ribs to the walls of the building, making the combination load-bearing.

Muqarnas, on the other hand, is built on suspended layers, which does not necessarily have the same material of the building. These layers are prepared separately on the ground and later they are attached to the wall or ceiling. Finally, after installing the suspended layers, the space between them is filled with ornamental constituent elements. Having at least three tiers, *Muqarnas* should include horizontal *takht* elements. The load of the decorative is transferred to the supporting ceiling or walls by tensile elements, such as rope and timber. Hence *muqarnas* is considered a purely decorative structure. The first recorded sample of *patkaneh* was constructed in mid 10th century in Iran, whereas mature *muqarnas* was developed in the early 14th century.

1.8 Significance of Research

This research intends to establish the evolution of the structure known as *muqarnas* from its functional origins, i.e. squinch. Although squinches are accepted as the predecessors of *muqarnas* in Iran, but the gap between these two structures is very big and there has been no explanation about the process of evolution of the structure. This big gap which has never been bridged since 1977 will be clarified based on the results of this research. As mentioned before, the reason behind not finding the missing link between *muqarnas* and squinch is in fact the uncertainty about the definition of the structures and their characteristics. Hence, misinterpretation of several pseudo-*muqarnas* structures as *muqarnas* is observed in many scientific publications.

The connecting link that is called *patkaneh* has to be introduced to the body of knowledge and studying the gradual evolution of *muqarnas* from squinch is only possible by detailed review of these structures. To the author's best knowledge, this

is one of the first attempts in studying *muqarnas* that reviews all the details of the structure, including its constituent elements, as well as the structure's other specifications, namely, chronology, form and structure, and construction techniques.

1.9 Research Scopes

The effective historical period in the scope of this research is from pre-Seljuk to Ilkhanid, i.e. from 10th to 14th century. This period was chosen for two main reasons. With reference to standard contemporary *muqarnas* patterns of Morocco, Necipoglu mentions that although efforts have been made to add innovative designs, one can conclude that since the 14th century the rules governing the elements and details of designing Moroccan *muqarnas* have not changed and creativity can only be observed in applying novel proportions of elements and tiers in the structure (Necipoglu, 1995). Iranian *muqarnas* and Moroccan *muqarnas* have similar basic characteristics, with *taseh* and *shaparak* as their main constituent element. However, they are built using different construction technique and material. Based on the axial coding of the gathered database of 100 *muqarnas* and pseudo-*muqarnas* structures in Iran, the author concluded that Necipoglu's theory about Moroccan *muqarnas* can be extended to Iranian *muqarnas* as well. In other words, the forms in Iranian *muqarnas* have been also fully developed by the 14th century and then after only minor innovations are observed in the composition of elements with respect to each other.

Studied samples are selected from hundreds of available *muqarnas* and pseudo-*muqarnas* structures inside the geographical region of Iran. These 100 samples were intentionally chosen to from specifically important buildings, in terms of architectural history, based on the opinions and publications of world-famous archaeologists, and architectural historians who studied this region (Pope, 1965; Blair & Bloom, 1994; Godard, 1965). Finally, this region had been selected for four main reasons. First, there are reliable theories that seek the origins of *muqarnas* in

Iran. Second, there is a rather rich literature about the architecture of Iran during Seljuk and Ilkhanid periods. Third, the significant role of Seljuk architecture in Iran, on the expansion of these forms and structures to other parts of the world should not be neglected (Edwards & Edwards, 1999; Bloom, 1988), and finally, the importance of the author's practical and academic knowledge about the traditional architecture of Iran, which is obtained by working with great masters of traditional architecture, as well as being involved directly with constructing *muqarnas* for many years.

1.10 Research Limitations

There have been great limitations on the study of *patkaneh*, as the topic is newly introduced as a scientific issue, and hence, one can hardly find any available literature on the topic. The unknown and confusing concepts and key words required to define the structure were also influencing the research. There is a wide variation in the structural characteristics, applications, and dimensions of the studied samples. In many cases, in order to find out more about the structure's construction techniques and doing some measurements, it was necessary but impossible to access the hidden parts of it. Furthermore, many samples are now located within the political borders of other neighbour countries, such as Iraq, Afghanistan, Syria, and etc., which were not accessible due to political instability and continuous civil unrest, except the one in Samarqand, Uzbekistan.

1.11 Thesis Structure

This thesis is organized in six main chapters. Chapter 1, the current chapter, looks mainly on the significance of the research topic and provides general

information about the major concepts dealing with the research. The scopes and final contributions of the study are also explained and elaborated in this chapter. Chapter 2 is arranged to provide a comprehensive review of the available literature about *muqarnas* and its path of development and evolution as well as the definitions offered so far for *muqarnas* and its constituent elements, where as the methodology of the research is completely explained in the 3rd Chapter. Chapters 4 and 5 are where the gathered and recorded research data are presented, depicted and analyzed in detail. As the predicted results of the first objective were necessary to proceed with the investigation, it was studied, concluded and validated in Chapter 4, and then the results were used to proceed with the study in the next chapter. Finally, a conclusion of the whole research and the achieved goal is introduced in Chapter 6. A list of cited references is provided after the last chapter and there is a complete set of appendices including all research data, for any further inquiries.

1.12 Summary

As the scope of this research on tracing the evolutionary path of *muqarnas*, the structure and its filiations are sought and their detailed characteristics are clearly studied, to resolve the misunderstanding about the definition of the structure, using a qualitative approach. A database of available *muqarnas* and pseudo-*muqarnas* samples in Iran is collected and the three-dimensional patterns and two-dimensional plans of the studied structures are created to facilitate the understanding of the similarities and differences of the aforementioned structures and their architectural characteristics, i.e. their structural role, as being load-bearing or merely decorative, their construction technique and the complexity of their geometry through time, using an inductive method. Based on the outcome of this research, after clear definition of *muqarnas* and its constituent elements, *patkaneh* will be introduced as the precedent phenomenon leading to the creation of *muqarnas*. Referring to the achieved definitions, the gradual development of squinch toward *muqarnas* will be then demonstrated in detail.

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