ICONARP
International Journal of Architecture and Planning
Received: 14.12.2022 Accepted: 23.05.2023
Volume 11, Issue 1/ Published: 27.06.2023
Research Article *DOI: 10.15320/ICONARP.2023.237 E- ISSN:2147-9380*
ICONARP

Reproduction of Architecture in Modernizing Local Architecture: The Case of Muqarnas

Motasem Issa Mahmoud Abu Zer*
Kader Reyhan **

Abstract

The present study aims to investigate the cultural identity concept and its relation to cultural heritage within a conservation framework under the threat of unfettered interventions for modernity and its requirements by analyzing the reproduced architectural works. Furthermore, the study focused on clarifying and tracking the effects of architectural reproduction on society and individuals, as well as on the local way of thinking and local culture in a specific region known as the "*Levant.*" The research method is developed in two interconnected ways: qualitative 'interpretive' research methods are used to explain the pure concept of cultural heritage, while a 'simulation strategy' is used between traditional and historical architectural elements to create new architectural elements with historical origins and contemporary touches. Construct logic is a method of "*modernizing local architecture*", in that it controls modern architecture and uses it to develop local architecture rather than obliterating and distorting it. "*Muqarnas*," one of the Islamic architectural decorative elements widely used in the Levant and surrounding geography, is chosen as the simulation case study for developing new contemporary architectural elements used both structurally and decoratively. The simulation approach used in the study is limited to several traditional architectural elements from the study's historical and cultural context, which were documented with architectural and technical data as well as illustrative drawings. It may be possible to raise conservation awareness by simulating some traditional architectural elements and developing them in a highly technical environment. Furthermore, it can provide the opportunity to obtain new architectural elements of a contemporary cultural nature that resist architectural reproduction in a variety of internal and external fields, as well as structural solutions.

Keywords:
Architectural reproduction, cultural heritage, globalization, muqarnas, simulation strategy.

*Eskişehir Osmangazi University, Department of Architecture, Eskişehir, Turkey.
E-mail: abuzer.motasem@yahoo.com

**Eskişehir Osmangazi University, Department of Architecture, Eskişehir, Turkey. (Corresponding author).
E-mail: kreyhan@ogu.edu.tr

To cite this article: Abu Zer, M., & Reyhan, K. (2023). Reproduction of Architecture in Modernizing Local Architecture: The Case of Muqarnas. *ICONARP International Journal of Architecture and Planning,* 11 (1),155-180. DOI: 10.15320/ICONARP.2023.237

INTRODUCTION

Different cultures have emerged around the world as a result of integrating the natural environment with the local living conditions of each region, each with its environment, sources, and languages. Cultural identity becomes a pattern and an integral part of daily life to express societal values based on these cultural expressions created as traditions (Li, 2017). Given such scope, Madanipour (2003) argued that cultural identity was the primary component of place memory, which can be considered one of the most important pillars of cultures and societies. According to Bachelard (1994), compressed time in a specific unit of the earth produces a variety of memories, which when combined create a unique memory of the place. This memory contains details about the place and stimulates its distinctive qualities and characteristics, which can be referred to as cultural identity. According to Bell et al. (1996:306), identity belongs to places and individuals, beginning with personal space and progressing to public space (Figure 1). Identity is a critical component of society's structure for the formation of social and cultural links and cannot be ignored.

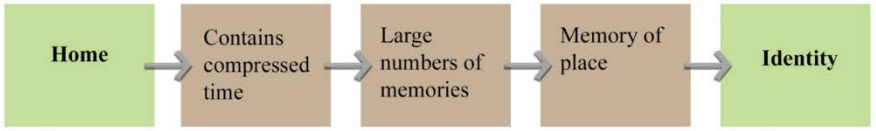


Figure 1. Shaping cultural identity within a place (Source: Authors)

However, it is undeniable that the world is constantly evolving functionally, economically, and technologically, resulting in continuous growth situations for living requirements (Ouyang, 2016). As a result, globalization has taken hold, assisting in raising living standards and meeting basic needs while also erasing cultural differences and traditional styles, transforming the entire universe into a small town where all elements and forms are shared. This is known as "*architectural reproduction*" because the universal style serves as the foundation for all design standards used worldwide (Jokilehto, 2010). According to Navickienė & Riaubienė (2018), international concepts such as "*heritage conservation*" have been developed to achieve a balance between contemporary "*functional and economic*" requirements and cultural diversity within natural habitats. The concept of "*heritage*" has influenced how the term "*conservation*" has been used throughout history (Rahman, 2012). Larkham defined heritage as "*simply all things to all people*" (1995: 85; Figure 2).

DOI: 10.15320/ICONARP.2023.237

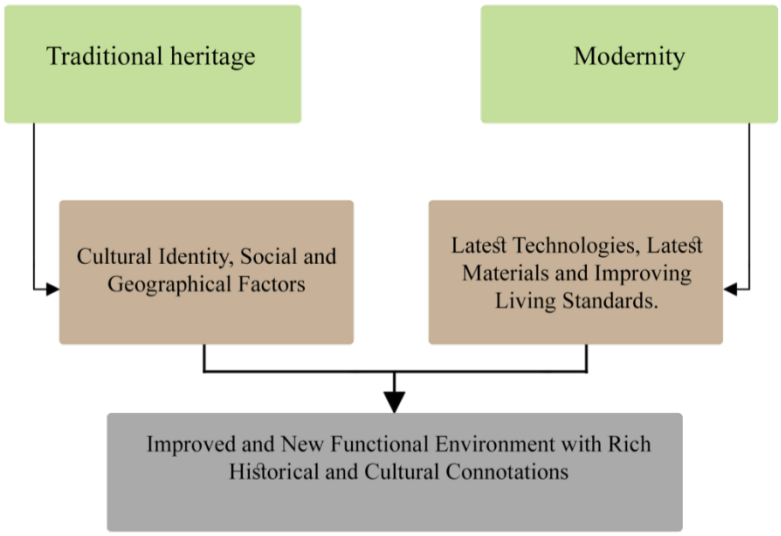


Figure 2. Characteristics of modernity and heritage and their balancing relationship (Source: Authors)

According to Ouyang (2016), the phrase "*heritage conservation*" has coexisted with other terms such as "*modernization of traditional architecture*" and "*localization of modern architecture*", where all three terms originated from the same source and were all developed to preserve cultural diversity, traditional daily life, and customs while also integrating them with contemporary technology to achieve the following goals:

- Keeping up with economic developments and new functional requirements.
- Preserving the spatial structures and the surrounding environment.

Heritage, on the other hand, can be preserved and national identity can be accentuated within the framework of awareness-raising and education policies that emphasize the importance of national identity in terms of its distinctiveness in the artistic, cultural, and intellectual aspects of societies and individuals, but that it shares the human aspect with all other civilizations and societies (Brockhoff et al., 2015). As a result of such awareness and educational policies, it is possible to avoid turning cultural, artistic, and intellectual diversity into a source of conflict and hostility within or between societies.

RESEARCH METHODOLOGY

Modernity and its demands for architectural reproduction, facilitated by globalization, pose a threat to cultural identity and the relationship with heritage. To draw away such threats, qualitative "*interpretive*" research methods were used in the present study to explain the pure concepts of cultural identity, cultural heritage, and architectural reproduction within the conservation framework. Simultaneously, a "*simulation*" strategy between traditional and historical architectural elements has been used to create new architectural elements within the historical origins and contemporary ways. This is to demonstrate an approach towards "*modernizing local architecture*", through which the process controls modern architecture and turns it into a tool for developing local architecture rather than exterminating it (Figure 3).

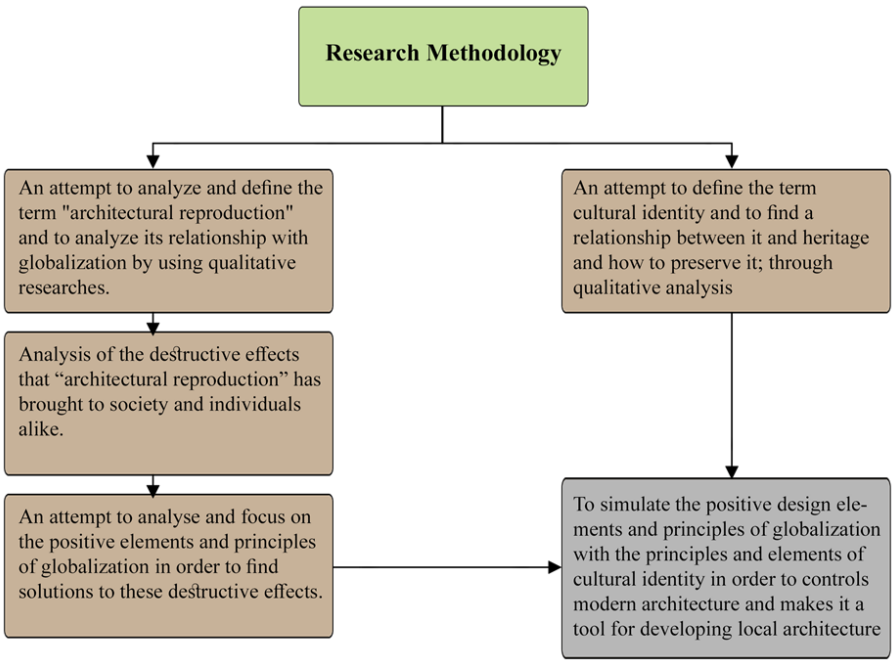


Figure 3. The research methodology (Source: Authors)

THE PURE CONCEPT OF IDENTITY, REPRODUCTION, AND GLOBALIZATION

Despite the difficulty in defining identity, Arnett Jensen (2003) developed an identification and demonstration framework based on the definition of identity characteristics, their formation and relationship to individuals and communities, and the details of everyday life. According to Shweder et al. (1998), behavioral practices that unite people within a community can involve the formation of a cultural identity. Furthermore, according to Whiting & Child (1953), cultural identity encompasses a wide range of spiritual, religious, and moral beliefs, as well as behavioral practices, thus the relationship between these cultural beliefs and practices becomes the main pillar of society.

According to Madanipour (2003), cultural identity can be considered one of the most important pillars of cultures and societies, as the main component of the memory of the place. Bachelard (1994) argued that compressed time in a particular unit of the earth creates a wide range of memories, which then together create a unique memory of the place. This memory contains details about the place and stimulates its distinct character and unique value, which differentiates it from others and is referred to as cultural identity. According to Bell et al. (1996: 306), identity belongs to places and individuals, beginning with personal space and progressing to public space. Identity is an essential unit in the structure of societies for the development of social and cultural ties and it cannot be neglected.

The Relationship between Cultural Heritage and Identity

Identity is the foundation of societies, as it reflects cultural and architectural aspects. Its existence indicates the existence of people and is the determinant of both private and public spaces. Furthermore, identity serves as a springboard for daily expressions and social

DOI: 10.15320/ICONARP.2023.237

interactions that reflect the spirit, language, and physical conditions of the urban environment (Turner & Singer, 2015). Once threatened, the architectural and cultural heritage is at risk. As a result, identity is an essential component of heritage, and the process of preserving heritage in its various forms and patterns must include the preservation of cultural identity. However, the concept of heritage had not previously been fixed or defined, thus the definition of heritage passed several stages, such as world wars, and periods of occupation and destruction, which had the greatest impact on shaping the concept of "*heritage*" over decades.

1st Definition **of "Heritage" after WWI**: According to Behiri (2011) "*Heritage is a symbolic resource, strongly linked to the question of collective memory and identity.*"

2nd Definition **of "Heritage" after WWII**: According to Graham (2011: 94), "*the content of heritage is commonly seen as embracing both the tangible (natural landscapes, buildings, monuments, and the like) and the intangible (folklore, rituals, traditions, faiths, myths, and others).*"

3rd Definition **of "*Heritage*" in the 1960s-1970s:** Park and Allaby (2017: 13) describes heritage as follows: "*Heritage must be seen as separate from the pursuit of history, as it is concerned with the re-packaging of the past for some purpose in the present.*"

Following the development of modern movements in the Arab world between 1980 and 1990, and following Western trends, national identity began to be lost to meet modern requirements. Under the pretense of "*conservation,*" new concepts have emerged to reduce modern incursion and develop and preserve Islamic heritage content (Bagader, 2016; Ouyang, 2016), such as:

- Localization of Modern Architecture
- Modernization of Local Architecture

The development of identity and local heritage within the framework of the new preservation approach based on modernization and localization creates an atmosphere based on enjoying architecture without the need for a translator, resulting in an emotional rapprochement between the material and human fabric. When the viewer's relationship with the building reaches a critical threshold and he becomes aware of his own identity.

The Concept of Reproduction and Globalization

Globalization is a multi-faceted process with political, economic, and social dimensions and has architectural and cultural implications. According to Adam (2008), globalization emerged to create global social relations, a global economic market, and a unified global identity "*to eliminate aggressive nationalism and strengthen social ties around the world*". According to Barr, Hitchcock, and Johnson (1995), an attempt was made to reverse this architecturally by constructing identical iconic buildings around the world with specific and pre-determined standards according to the international style. The concept of "*architectural reproduction*" began to emerge here.

Koolhaas et al. (1995) also claimed that globalization had an architectural face that transformed ordinary countries into global attractions by converting money into tourist attractions, and these "*cloned and similar buildings*" acted as economic engines to increase capital. Yet, the question arises: "*The iconic and global products had been created to attract visitors, but they became similar everywhere, so what is the need for a visit to distant countries to see those products while they can be seen anywhere?*". Frampton (1993) discusses how modern civilizations incorporate elements of scientific, technical, and technological rationalism, as well as political rationalism, into mass production. Furthermore, Tzonis (2008) contends that globalization is the result of a long-term process of transportation and communication innovations.
However, based on actual outcomes and Adam (2008) and Madanipour (2003), it is possible to conclude that these concepts and principles emerged with globalization, particularly the principle of redefining and unifying stereotypes and sensations such as "*luxury, beauty, strength, and sustainability*" to market and promote policies, economies, standards, and Western influence, led to creating the concept of architectural reproduction through a global architecture that shares same elements, concepts, and principles. As a result, destructive effects in societies were created, with "*cultural occupation*" being one of the most crucial components of these effects (Figure 4).

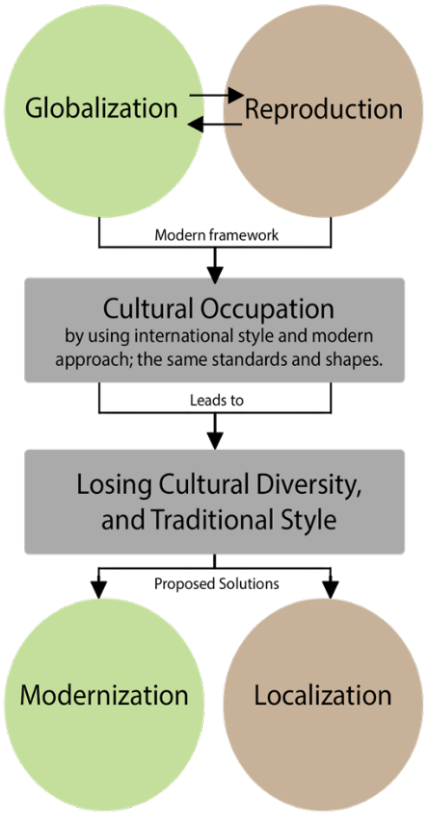


Figure 4. The destructive effects of Globalization [Source: Authors, based on Lefaivre & Tzonis (2012) and Tzonis (2008)].

Cloned architectural "*reproduction*" can lead to a so-called cultural occupation, which locks cultural identity and biological diversity behind modernity's bars with the locks of Western standards and policies.

DOI: 10.15320/ICONARP.2023.237

Furthermore, there are numerous other negative consequences of architectural reproduction resulting from globalization, such as:

• ***Create a social gap*** (Tzonis, 2008) due to the high cost of creating modern buildings.

• ***Eliminate the creative nucleus*** that has produced the great civilizations of the past through cultural diversity (Frampton, 1993).

• ***Environmental wastefulness*** (Lefaivre & Tzonis, 2012).

In the present study, localization and modernization are proposed as solutions to the destructive effects of globalization, which result in the loss of cultural diversity and cultural heritage from past lifestyles.

APPLICATIONS OF LOCALIZATION AND MODERNIZATION: THE CASE OF MUQARNAS

According to Li (2017), certain conditions must be met during the application of "*localization*" and "*modernization*" to maintain their methodology and the desired goal (Table 1), including:

A) Preserving the Indigenous Population after the modernization and localization processes have been completed, thus the Indigenous people are the true definition of spatial identity.

B) Upholding traditional customs and improving quality of life.

C) The functional spaces should continue to be used as a continuation of social activities in everyday life.

Table 1. The goals of localization and modernization (Source: Authors)

Process	Goal
1-Simulation with architectural elements	Acquire new architectural elements with historical characteristics and conventional sources with modern touches
2- Simulation with structural elements	Its goal is to revive old structural formulas and geometric formations based on traditions and practices.

According to Ouyang (2016), systematic localization and modernization processes aim to use modernity's characteristics and features and simulate them with the cultural and historical connotations of each region. Furthermore, one of the most important applications of "*modernizing local architecture*" is to simulate traditional heritage elements with each other using modern technological means and materials. Therefore, *muqarnas* of the Islamic heritage in the Levant was simulated with other traditional architectural and structural elements since it was a highly adaptable element with advanced geometry that adapt to several formworks. *Muqarnas* could also be designed to simulate other architectural elements to acquire new architectural elements (with Islamic roots and a contemporaneous identity) without misrepresenting Islamic architecture with massive glass facades cloaked in modernity and contemporaneity.

There is no doubt that the following factors should be considered to improve Islamic architecture generally and *muqarnas* in particular (Maskin, 2019):

ICONARP – Volume 11, Issue 1 / Published: 27.06.2023

1. Become attentive to structural proportions

2. Using geometrical vocabulary, assess the aesthetic unity and decorative details

Furthermore, *muqarnas* may continue to evolve indefinitely to survive. Such a well-defined structural feature with varied and intriguing ornamentation can be used in a variety of contexts.

A framework was used to define the process of simulating *muqarnas* with other architectural elements so that the simulation process is based on achieving functional, sustainable, and aesthetic goals that are proportional to the needs of the time, but without losing the spirit and pure concept of *muqarnas*. Furthermore, this framework is critical in the evaluation of the simulation outcomes.

The methodology used in the present study is based on analyzing ancient and modern historical cases of *muqarnas*, which demonstrate how *muqarnas* have evolved and survived over time. After mastering the fundamentals of *muqarnas*, they were combined with architectural elements to create brand-new elements with a "*modern Islamic identity*" that could be applied as "*decorative and structural solutions*" in a variety of interior and exterior domains. Figure 5 depicts a flowchart of the methodological technique for modeling *muqarnas*.

Although *muqarnas* are an Islamic product, there is no information on where they were first used. While some early *muqarnas* monuments show its geometrical forms and construction techniques in various regions, including the center of Iran's northeastern region and Northern Africa, the first *muqarnas* were reportedly discovered in Iran in 1968 at the Takeht-I-Sulayman castle in Buchara, the Ismail Samani Mausoleum, and the Mausoleum of Arab-ata in the town of Tim, according to DoldSamplonius and Harmsen (2005) (Near Buchara). The first known example of *muqarnas (stalactite vaults)* was discovered in ImmDuva's tomb. Furthermore, *muqarnas* also appeared as a design feature to conceal and divide squinches, as well as to improve the decorative value of the squinches' and enrich the Islamic identity. These "*splits*" evolved into more sophisticated, consolidated, and functional components in decorative structural fields over time, as seen in the Samanid Prince Ismail Tomb in Bukhara, Uzbekistan (Figure 6).

DOI: 10.15320/ICONARP.2023.237

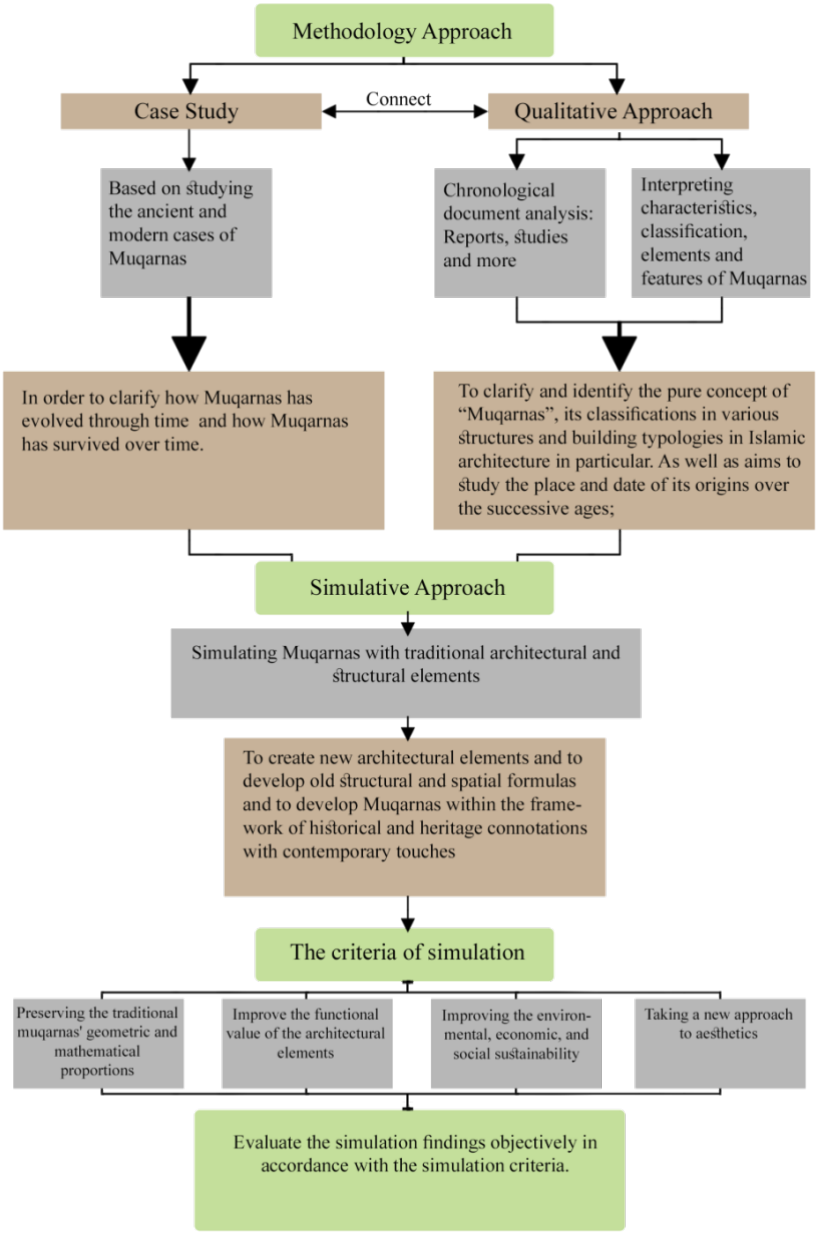


Figure 5. The Methodology Approach for Simulation (Source: Authors)

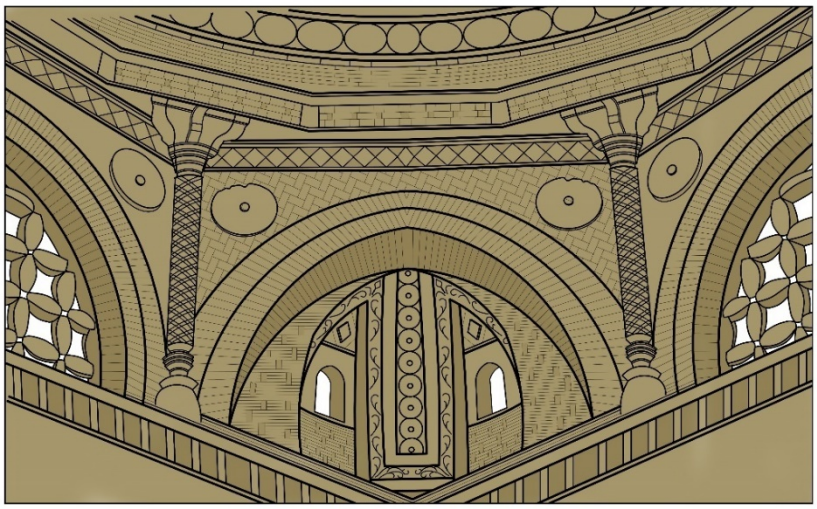


Figure 6. The transition zone of Bukhara's Samanid Prince Ismail Tomb (Source: Authors, based on Hattstein, M. and P. Delius 2000, p. 115).

The Basic Elements and Principles of Muqarnas

The outside of the muqarnas typically resembles the stalactites that form naturally in caves. According to van den Hoeven & van der Veen (2010), the "*stalactite vault*" is known in the Levant as "*muqarnas.*" Furthermore, Maskin (2019) argued that this motif is also common in Islamic culture and resembles stalactites; when combined, it takes on the shape of structural vaults.

The conversion of Islamic patterns and motifs (Arabesque) from two to three dimensions, which represent Islamic lifestyle, architecture, art, and societal design, could have been the fundamental design element of *muqarnas* (Castera, 2003). Figure 7 depicts this point of view.

Figure 7. The composition concept for muqarnas: a design transition from flat patterns to structural elements (Van den Hoeven & van der Veen 2010, p.1).

Muqarnas were also seen as support structures that distributed load like flying buttresses by Creswell (1952), Bloom (1988), and Imani (2017). Although it can be found in almost all Islamic structures, mosques, and mausoleums are said to have more of this distinctive architectural element. Despite the wide range of architectural styles found in each country, this architectural feature unites the Islamic world. It was discovered in Egypt, Turkey, Iraq, Iran, Syria, Andalusia, and the Maghreb, among other places. Muqarnas are decorative and structural elements found in a wide range of buildings, including facades, domes, arches, and entrance portals.

According to the previously mentioned characteristics and composition of *muqarnas*, it is made up of "*cells*" that are connected by intermediary elements. The *muqarnas* elements are grouped in layers, or "*tiers*". According to al-Kashi (1960), these intermediary components are as follows:

The *muqarnas* is characterized as "*a roofed (musaqqaf) [vault] resembling a stairway (madraj-*مدرج*) with facets (dil'-*ضلع*) and on the part of a roof*" (*sateh* -سطح). Each side makes a right angle with its neighbor, a half-right angle with it, and their total, or integration among these two. The two sides can be represented as being on a plane parallel to the direction of the horizon. It has either two surfaces, one flat and the other curved, that make up its roof, or one surface that is not parallel to the horizon. According to al-Kashi (1960), both facets and their ceiling are referred to as unit cells (*baayt-*بيت). Al-Kashi additionally split the cell into two parts (the roof and the side component) to simplify arithmetical computations and identify *muqarnas*' flatness in the simplest manner (Figure 8).

DOI: 10.15320/ICONARP.2023.237

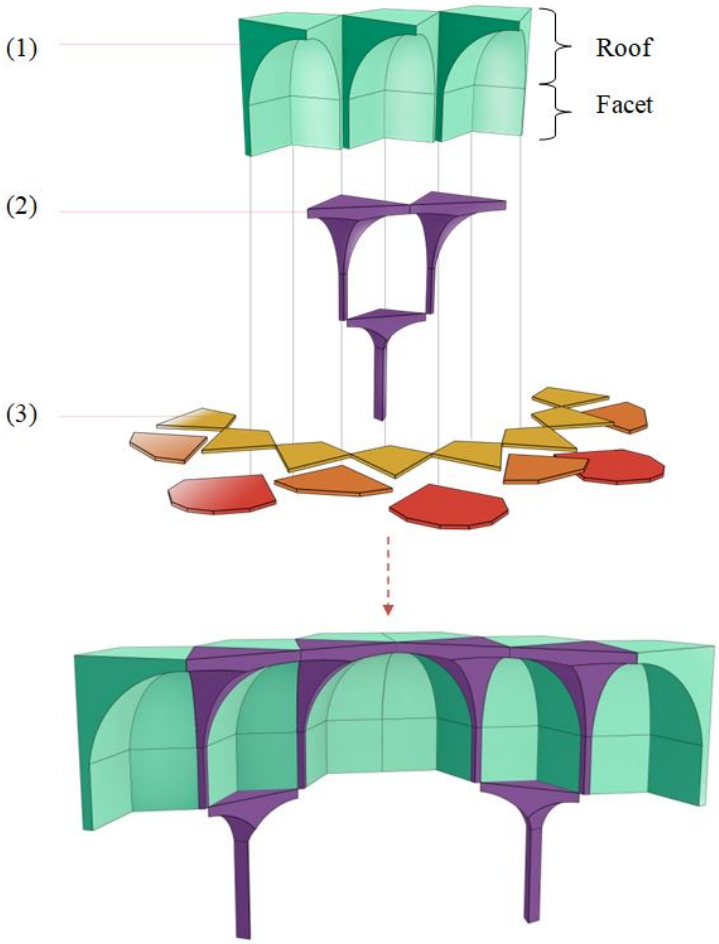


Figure 8. The fundamental elements of a muqarnas. (Source: Authors. Drawings were inspired by al-Kashi's (1960) descriptions).

Muqarnas patterns and classifications

One of the primary goals of *muqarnas* in a wide range of Islamic architectural heritages is the seamless transition from the quadrilateral shape of the dome to its circulatory shape. The layout of the *muqarnas* connected the cupola to the surrounding square-shaped walls. *Muqarnas* were used as ornaments in both cultural and social structures to convey the aesthetic value of Islamic civilization (Carrillo, 2016).

Muqarnas is created by manipulating surfaces that are connected horizontally and vertically by intricate geometric shapes, interlocking, and fractal elements. The elements and shapes of this fractal *muqarnas* are the product of mathematical operations and algebraic equations. According to van den Hoeven and van der Veen (2010), it is reasonable to conclude that the first *muqarnas* were composed of a limited number of basic types and components that, when combined, produced a wide range of parts. These diverse groups of elements can be organized into strata (layer-طبقة), and these strata can be combined to create various molds of *muqarnas* (Figure 9).

Figure 9. A muqarnas illustration from the Topkapi Inscriptions (Asad, 1995, p. 352).

Based on al-Kashi, Dold-Samplonius (1992) also noted that the fundamental design components of the *muqarnas* were made up of intermediate elements and cells. These cells, which appear to make up a small percentage of the vault, house the body of *muqarnas*. The intermediate parts are used to connect and combine the cells. In terms of classification and type, *muqarnas* are divided into two categories:

1. The first group was classified by early researchers using mathematical approaches based on al-Kashi (1960), who stated that there were four different types of *muqarnas*: "*The simple muqarnas: only plane surface; the clay plastered muqarnas: similar to the simple muqarnas but the tires are not all of the same height; the curved muqarnas: curved surface and the plan all consist of triangles and quadrilaterals; the Shirazi Muqarnas: other polygons such as pentagon, hexagon, octagon, and multi-pointed stars*".

2. Takahashi (1973, 1982) provides the second distinction of *muqarnas* types, categorizing them into three major styles: "*The square lattice muqarnas (developed in the 11th century), the pole table muqarnas (15th–17th century), and 'Other Style' muqarnas"*, (Table 2).

Table 2. Muqarnas categories were defined by Takahashi (1973, 1982).

	Types	**Features**	**cases**
a.	*Muqarnas* with square lattices first appeared in the eleventh century.	• Squares and 45-degree rhombus shapes were arranged to cover the top sides of the *muqarnas*. • Has a quadruple reasonable symmetry.	Granada's "*Hall of the Abencerrajes*", the Alhambra palace (Figure 10)
b.	*Muqarnas* (pole tables)	• Not being a direct connection between *muqarnas* and architectural structure; "The elements are created separately. After this phase, it is attached to the architectural structure using the ribs system."	Isfahan's Shah Mosque (Figure 11)
c.	Other-Style *Muqarnas*	• not included in the initial two categories	Mosque of Süleymaniye in Istanbul, Turkey (Figure 12)

DOI: 10.15320/ICONARP.2023.237

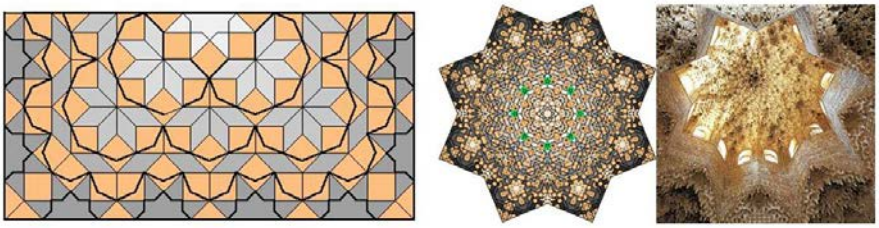


Figure 10. Square lattices. Alhambra Palace in Granada - Hall of the Abencerrajes. (Source: Van den Hoeven & van der Veen, 2010, p. 2-3)

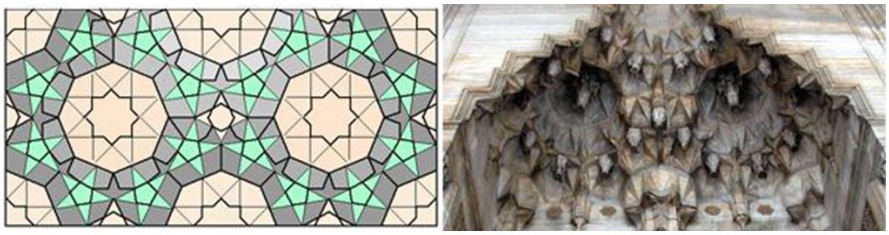


Figure 11. Pole table: The design and a picture of the Shah Mosque in Isfahan. (Source: Van den Hoeven and van der Veen, 2010, p. 3)

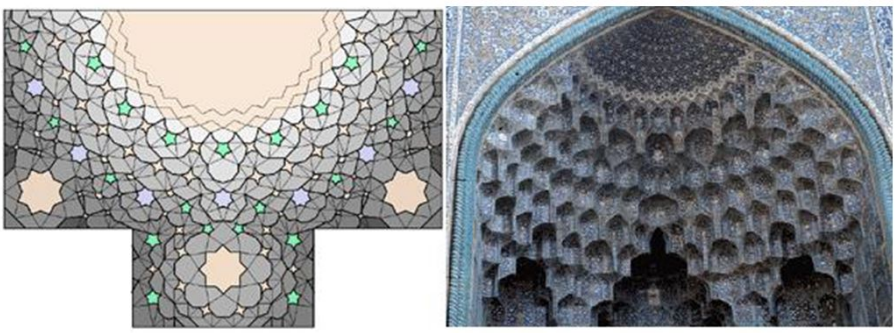


Figure 12. Other styles: Muqarnas designed by Sinan in 1557 in Süleymaniye Mosque in Istanbul, Turkey (Addressed by Van den Hoeven and van der Veen, 2010, p. 3).

Muqarnas has received attention in the past and present during many historical eras, particularly during the Islamic era between the tenth and sixteenth centuries, as evidenced by cases of their transformation from traditional to modern forms. According to Ömer (2011), modern initiatives to update how the *muqarnas* are used have also emerged, all while claiming to uphold the original vision of the *muqarnas* as a collection of structures, monuments, and ornamental formations for the twenty-first century. These approaches are examined and analyzed in this chapter to determine how they uphold the fundamental concept of muqarnas.

To begin, scientific and technological guidelines and standards based on traditional *muqarnas* must be developed to aid in the assessment of current situations. These guidelines and standards must preserve the original identity of *muqarnas* while simplifying their application. Furthermore, these criteria are derived from analysis and understanding of the geometric patterns and ratios of conventional *muqarnas*. According to Imani (2017), the following criteria were obtained under "*geometrical characteristics*": 1) The fundamental component, 2) Isometric, 3) Types of basic elements, 4) Basic module, 5) The basic module's element types and numbers, 6) Isometric types of modules, 7) Number of layers.

These geometrical characteristics of traditional *muqarnas* Based on Imani (2017) were presented in Table 3, from which contemporary cases will be evaluated and the following guidelines will be deduced:

Guide 1: Squares and rhombuses are the most important design elements in all six case studies of historical *muqarnas*.

Guide 2: The essential components are rotated through the angles of 45°, 60°, 90°, and 180°.

Guide 3: Each module is composed of at least two and up to five smaller components, which include rhombuses, half-rhombuses, squares, half-squares, almonds, jugs, large bipeds, and small bipeds.

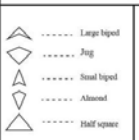
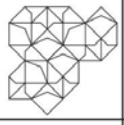
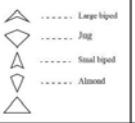
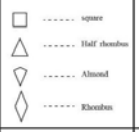
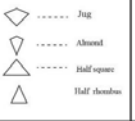
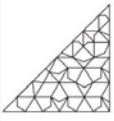
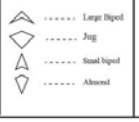
Guide 4: The basic modules in each of the six historical motifs are rotated at 45°, 90°, 315°, and 180°.

Guide 5: The number of layers in *muqarnas* compositions is determined by the composition's complexity. These six historical *muqarnas* specimens have three to six structural layers.

Guide 6: The golden ratio was commonly used in the composition of historical *muqarnas*.

Guide 7: Isometric baseline has four different types in all *muqarnas* compositions: rotation, reflections, translations, and glide reflection.

Table 3. Geometrical characteristics for traditional muqarnas (adopted from Imani, 2017).

Pattern's buildings	Basic elements	Isometry types of basic sector	Basic module	Number of basic module elements		Isometry types of pattern	Number of layers
pattern 1 Tinmal Mosque		Rotation 45°			5	Mirror 315° Mirror 90° Mirror 180°	3
pattern 2 II.Beyazid Mosque		Mirror 45° Rotation -45° Mirror 45°			5	Mirror 315° Mirror 90° Mirror 180°	3
pattern 3 Murat pasha Mosque		Rotation 60°			4	Mirror 45° Mirror 90°	5
pattern 4 Zisa Castle		Mirror 45° Mirror 45° Mirror 45°			2	Mirror 315° Mirror 90°	3
pattern 5 Selimiye Mosque		Mirror 90°			4	Mirror 315° Mirror 90° Mirror 180°	4
pattern 6 Sahabiye Madrasse		Mirror 90° Mirror 90° Mirror 180° Mirror 90°			4	Mirror 45° Mirror 90°	6

As a result, *muqarnas* can be described as an adaptable feature with an intricate configuration that can be merged with various architectural components to create *"modernized"* elements (with Islamic roots and contemporary touches) without misrepresenting Islamic architecture with enormous glazed facades imitating the modern and the contemporary.

DOI: 10.15320/ICONARP.2023.237

There is no doubt that the following factors must be considered to develop Islamic architecture in general and *muqarnas* in particular (Maskin 2019). Furthermore, it is possible to argue that *muqarnas* can continue to evolve indefinitely to survive.

As shown in Table 4, such a significant element with imposing ornamentation can be used in a variety of ways:

Table 4. Simulating the muqarnas utilizing different architectural and structural components

Operation	Main objective	Outcomes
1. Simulating *muqarnas* through the use of other architectural elements	Acquire new architectural elements with historical characteristics and traditional sources while incorporating contemporary meanings	The new interpretation of the conventional shading component "*Mashrabiya*", the new interpretation of Ottoman birdhouses, and so on.
2. *Muqarnas* simulation using structural elements	Its goal is to revive old structural formulas and spatial compositions based on cultural practices.	Created spatial spaces for various purposes such as commercial, religious, and so on.

The simulation criteria are summarized as follows:

- Preserving the geometric and mathematical proportions of traditional *muqarnas*
- Improve the functional value of the architectural elements
- Improving environmental, economic, and social sustainability
- Taking a new approach to aesthetics

Muqarnas Simulating Various Islamic Architectural Features

The renowned Islamic components are being modernized and repurposed with a contemporary take by using architectural principles for combining the elements and simplifying architectural concepts in the context of modern and current frameworks. As a result, traditional Islamic architecture is modernized while remaining true to its Islamic origins and references, rather than inflating and distorting the modernization image, which obscures national identity.

Simulation of *meshrabiyya* with *muqarnas* "*muqarnabiya*": *Muqarnas* and *meshrabiyya* are "*trademarks*" of Arab-Islamic architecture in Sham region, the Arabian Peninsula, and Egypt based on architectural observations (Abdelkader and Park, 2017; Maskin, 2019).

To be able to integrate and discover new architectural features, the merging and simulation procedures must be built on foundations and principles, in which the two elements are first simplified and abstracted, then demonstrate the design concept and the principles of their composition.

- Abstraction of muqarnas: The *muqarnas* structure is made up of cells, which appear in a variety of shapes but are most commonly observed as cubes. While studying the elements of the *muqarnas*, these cubes serve as the repeated unit of measurement (the module) (al-Kashi, [1427] 1960).

ICONARP – Volume 11, Issue 1 / Published: 27.06.2023

- Muqarnas design principles: The *muqarnas* design is based on fractal geometry, rhythmic scale, and harmonic repetition.

- Mashrabiya abstraction: *Mashrabiya* is composed of vertical modules that are repeated horizontally; it is frequently made of wood and features arches.

- Mashrabiya design principles: The horizontal integral repetition and the overlap concept form the foundation for the *mashrabiya* design's unit coverage.

After comparing and contrasting the two elements' principles and architectural design concepts, it is possible to conclude that they share several characteristics, such as the module and the norm of rhythmic recurrence, which allows their modules to be repeated and merged within the framework of *"fractal geometry"* to give the traditional *mashrabiya* depth and motion (Figure 13).

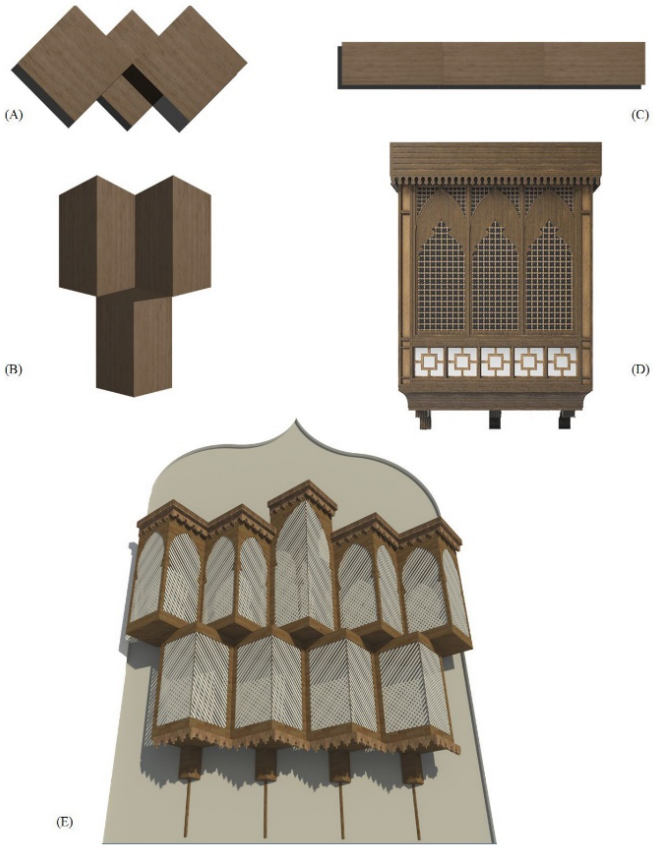


Figure 13. (A) the plan of *muqarnas*; (B) the 3D representation of *muqarnas*; (C) the plan of *meshrabiyya*; (D) the 3D perception of *meshrabiyya*; and (E) the simulated element "*muqarnabiyya*" (Source for A, B, C, and E: Authors.
Source for D: *ttps://3docean.net/item/Islamic-window-mashrabiya/23430425*).

According to al-Kashi's concept, the third element, *"tiers,"* can be used to increase the diversity of the construction of *muqarnas* within the context of *mashrabiya*, "*muqarnabiyya"*, resulting in a wide range of compositions. This is determined by the designer's effort and inventiveness, as seen in Figure 13 (E), which represents one of the described forms.

In this regard, it is possible to conclude that the (*muqarnabiyya*) element is a new architectural element resulting from the merging of the *muqarnas* with the *mashrabiya*, as the *muqarnabiyya* emphasizes the traditional touches by preserving the traditional geometric proportions,

DOI: 10.15320/ICONARP.2023.237

modularity, and harmonious repetition found in the traditional architectural elements. However, the contemporary aspect demonstrates that the *muqarnabiyya* consists of simple and clean masses without complex details and decorations.

***Muqarnas* simulating Islamic arches:** *Muqarnas*, as previously stated, is a technique for converting flat geometric patterns to multidimensional vision (Castera, 2003). These geometric and decorative patterns were defined by al-Kashi (1960) and later Takahashi (1982), and they have been used as a layer analogous to the horizon to construct cells and intermediate components on their top. However, the patterns will be applied orthogonally to the horizon, and the geometric components will be simulated with one of the remarkable arches in Islamic architecture, with the intersecting arches (Figure 14).

Figure 14. The intersecting arch (Source: *https://www.neh.gov/, date of access; 2022, December 5*)

To facilitate the merging and simulation processes, both the decorative and arch lines must be reduced and abstracted. Furthermore, *muqarnas* always relies on adding depth and a third dimension to the models. Instead of simply extruding the design lines, the vertical portions above the renewed arches and intermediate joining elements will be used to give the integrating procedure depth. Figure 15 shows how *muqarnas* simulation using Islamic archetypes achieves the desired result.

In this context, it is possible to conclude that the combination of *muqarnas* and intersecting arches resulted in a new architectural feature with the traditional touch of converting two-dimensional geometric patterns into three-dimensional architectural elements. On the other hand, the contemporary approach can be demonstrated by the resulting streamlined and elegant masses that are dynamically interconnected without delving into complex details, in addition to emphasizing the importance of arches as an architectural element and their proportions in the modern design process.

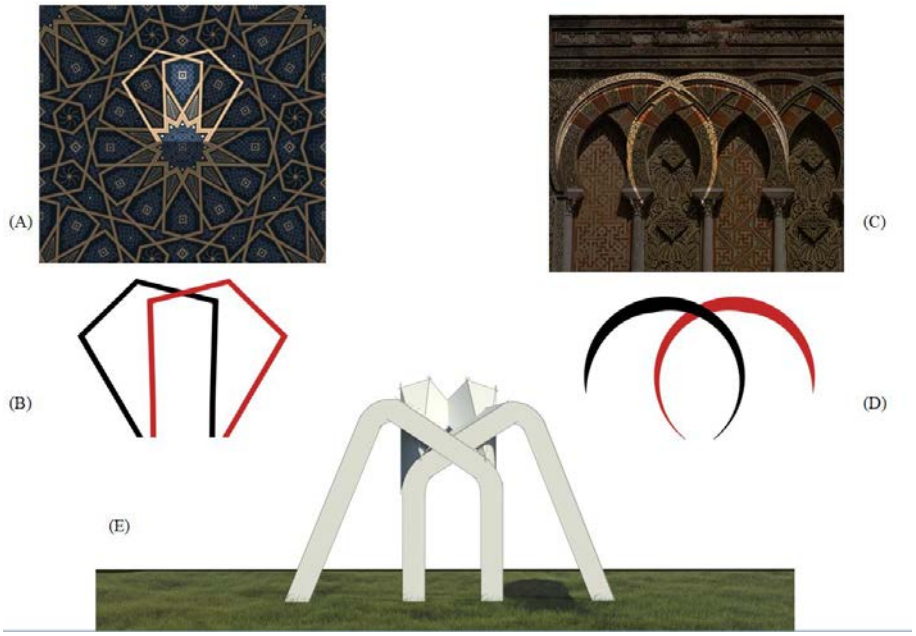


Figure 15. The design process for the renewed arch (Source for A and C: edited by the authors. Source for B, D, and E: developed by the authors)

***Muqarnas* simulating columns:** The simulation's goal is to modernize traditional architectural elements. Hence, Lang (2002) asserts that it is necessary to emphasize the following characteristics of contemporary modern architecture:

- Masses that are simple and neat.
- Modernity is dependent on the persistence of mass configurations and unity.

As previously stated, *muqarnas* can be abstracted with the cube serving as the primary construction component. It is also important to recognize that *muqarnas* is based on homogeneous sequences within the boundaries of geometric patterns. As a result, simulating *muqarnas* with columns in the modern era is based on geometric repetition within the cubic technique with a robust and consistent configuration of the masses. Figure 16 demonstrates how the *muqarnas* simulation with columns leads to the desired result.

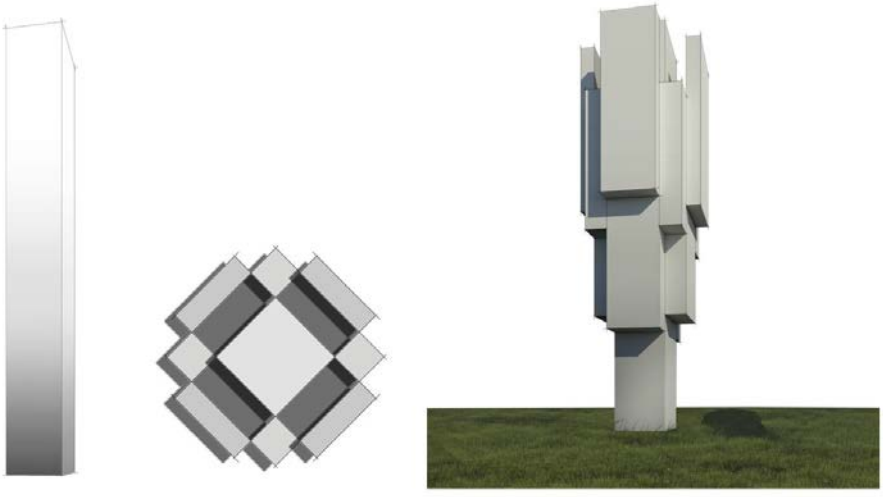


Figure 16. The design process for the renewed column. (A) is a regular column, (B) is a plan for a simple muqarnas, and (C) is a new column (Source: Authors)

As a result, it is possible to conclude that combining the *muqarnas* with the columns produced a new architectural element that bears the traditional *muqarnas* characteristics, such as the harmonious repetition

DOI: 10.15320/ICONARP.2023.237

of the masses and the depth given to the architectural forms. This merging implies dynamic movement in the composition while also being composed of interconnected and streamlined masses, which is a contemporary aspect.

***Muqarnas* simulating Flat *Mashrabiya*:** *Muqarnas*, as it is composed of several layers, is without a doubt a decorative architectural element used to add dimension and structural depth to the building (van den Hoevenand and van der Veen, 2010). This is accomplished by transforming two-dimensional lines into three-dimensional faces and surfaces (Castera, 2003), whereas the flat *mashrabiya* is used as a sustainable component to control lighting and ventilation (Li, 2018). However, the problem with flat *mashrabiya* is that it is not adjustable and is not appropriate in volatile situations. The flat *mashrabiya* will be simplified into repeated units called *"modules"* that fold and adapt to sunlight to develop it (Figure 17).

Figure 17. The process of designing the Adaptive Mashrabiya. A. 3D Muqarnas, B. Flat Mashrabiya, C. Adaptive Mashrabiya (Source for A and C: Authors. Source for B: *https://www.meashots.com/photo/210117/wooden-latticed-window-(mashrabiya)-with-two-small-swinging-sash.html*)

It contributes by introducing daylight without solar radiation; in other words, the surface opens based on the external temperature and time, *"when the sun is indirect."* However, it closes automatically when the sun is directly overhead and serves as a thermal and luminous barrier. As a result, a new, contemporary, and long-lasting architectural element based on traditional and cultural roots is created.

The combination of *muqarnas* and flat *mashrabiya* created a new architectural element that retains the traditional features, while adding a decorative and structural dimension to the elements while preserving the

ICONARP – Volume 11, Issue 1 / Published: 27.06.2023

effective function of the traditional *mashrabiya* in regulating lighting and ventilation by blocking heat without blocking the entry of sun rays, resulting in reduced energy consumption. The contemporary and modern aspects of this new element, on the other hand, are represented in an adjustable formation based on changing environmental factors while also providing a dynamic feature in the building envelope as it is formed of triangular planes, which are simplified and devoid of complex decorations.

***Muqarnas* Simulation with different structural elements:** *Muqarnas* should be simulated with other structural elements in a building to activate it as a structural and an independent element without the need for other supporting elements such as columns which could disrupt the interior design. The "*flying buttresses*", a traditional Gothic architectural structural element, are studied and modeled with *muqarnas* (Figure 18).

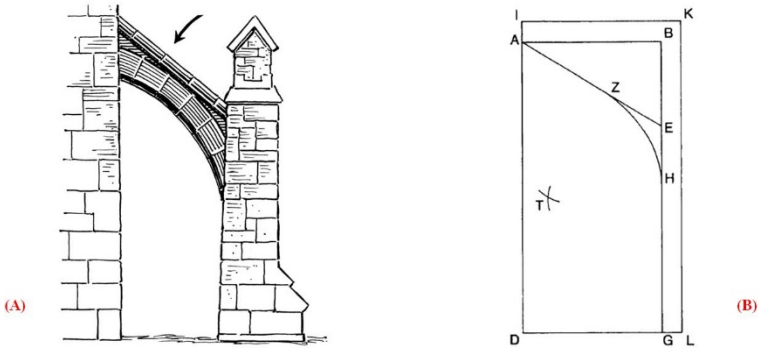


Figure 18. A flying buttress muqarnas simulation. A. The Flying Buttress (2022); B. Muqarnas' module (DoldSamplonius, 1992).

Given the long history of success of *"flying supports"* in Gothic architecture, it can be argued that they were used as a structural feature that redistributed loads (Nikolinakou, Tallon, and Ochsendorf, 2005). While *"flying buttresses"* necessitate precise calculations of the arch's drawing to avoid structural deformations in transferring loads (Verstrynge, Schueremans, and Smars, 2012). Figure 19 demonstrates the working principles of *"flying buttresses."*

DOI: 10.15320/ICONARP.2023.237

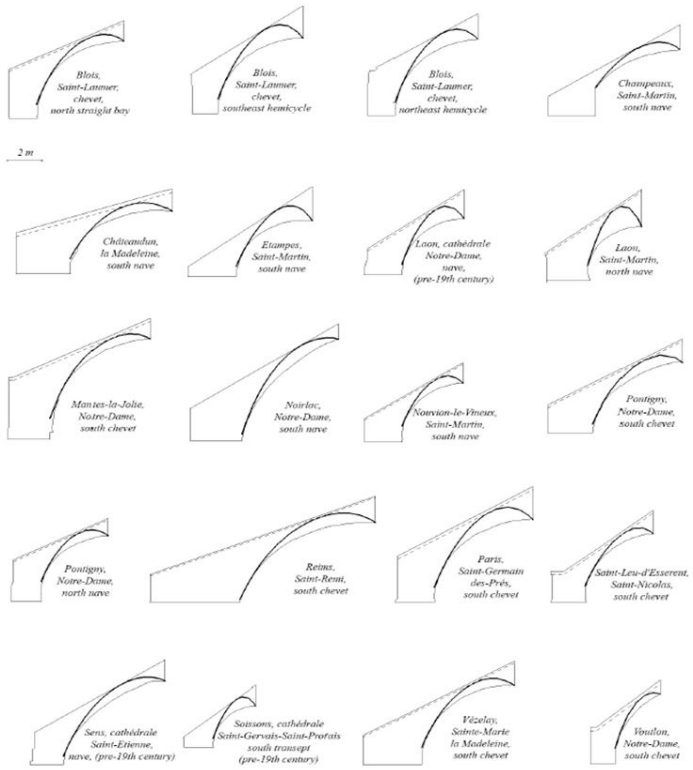


Figure 19. Structural analyses used for flying buttresses (Nikolinakou, Tallon, and Ochsendorf, 2005).

Muqarnas has also been successful in supporting a wide range of structures, including domes, half-domes, and even quarter-domes (Yaghan, 1998). There is, however, no known example of a structure made entirely of *muqarnas*. In the given example, the loads will be moved vertically between cells until they are fully transferred to the ground. The roof (the curved part of the cell) will be simulated using the proportions of the curved flying buttresses' parts to achieve the best load-transforming shape factor. When simulating the *muqarnas* with flying buttresses, an effective structural component *"capable of carrying itself and the weight of the building"* was created (Figure 20). Furthermore, to protect *muqarnas'* characteristics, it was designed within the confines of geometric shapes.

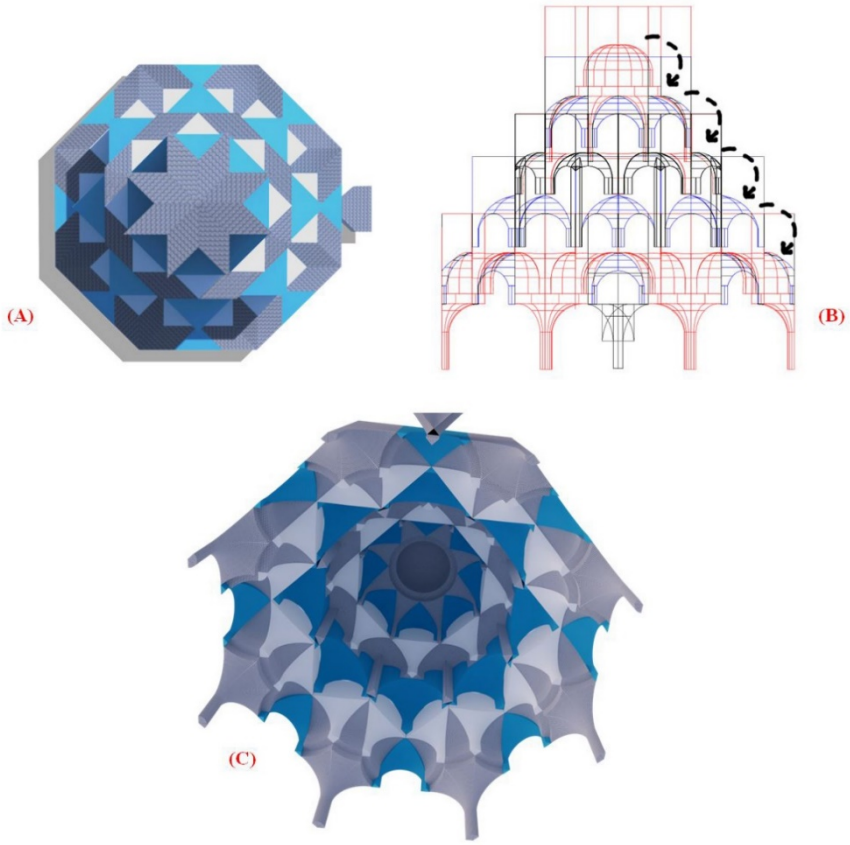


Figure 20. *Muqarnas* simulation with flying buttresses produces the following results: (A) a top view of the "*geometric design*", (B) an analytical illustration for load distribution, and (C) a 3D interior view of the "*muqarnas building*" (Source: Authors).

Given the approach described above, it is reasonable to conclude that combining and simulating *muqarnas* with other structural elements resulted in new structural elements with the characteristics and traditional shape of the *muqarnas*. However, the new element's contemporary and modern aspect lies in its function, where it can be claimed that the new structural element, as the constituent unit of the building, can carry itself in addition to the weight of the entire building, without the need for other structural elements like massive structural columns, which may lead to deformation in interior design.

CONCLUSION

Cultural identity can be defined based on three main aspects: "*identity as a sustainable cultural treasure*", "*identity as a cultural power*", and "*identity as a cumulative memory*". There is a link between geographical location and cultural experience, which helps shape identity characteristics as a long-term cultural heritage. It can be argued that the application of modern technological frameworks within the contemporary vision and cultural context, as well as national affiliation. Such an approach strengthens the ability of identity as a distinct cultural asset, where national identity has been the most successful modern apparatus for orchestrating belonging. Cultural identity can also be defined as a collective concept of all knowledge that directs behavior and

DOI: 10.15320/ICONARP.2023.237

experience in the interactive society framework and in repeated societal practice that occurs across generations.

As a result, as the primary component of a place's memory, cultural identity can be considered one of the most important pillars of cultures and societies. Identity is a necessary unit in the structure of societies for the development of social and cultural ties. It cannot be done away with. In the present study, *muqarnas* and its structural and formal characteristics were studied. The following highlights are the summary of these fundamental concepts:

- The fundamental idea behind *muqarnas* is to transform geometric patterns and motifs from a two-dimensional medium to a three-dimensional medium. *Stalactite vault* has been used to characterize *muqarnas*.
- Although there are several early indications of *muqarnas* in northeastern Iran and central North Africa, there is no documentation regarding the precise location of the first *muqarnas*.
- *Muqarnas* were first used as a decorative element to cover and divide squinches*. Muqarnas*, on the other hand, are decorative and structural elements that can be applied to domes, facades, entrance portals, arches, etc.
- *Muqarnas* uses fractals and interconnected parts that are linked by sophisticated geometric shapes in both horizontal and vertical transformations. These fundamental components are made up of tiers, intermediate elements, and cells.
- *Muqarnas* are constructed using a variety of materials because they are based on local materials in each location.
- *Muqarnas* have numerous architectural applications, and they can even be combined with other architectural features to create entirely new designs (with an Islamic root and a contemporary feel).

This study demonstrates an attempt to upgrade traditional architecture by incorporating *muqarnas* as new and contemporary elements into Islamic architecture. This is explained by al-*muqarnas*' reliance on geometrical and harmonic recurrence, as well as adaptability and structural integration. *Muqarnas* also provide structural value and depth. Furthermore, these architectural features were unique in that they served as both decorative and structural components.

Based on the newly discovered elements in the present study, it is possible to state that historical and traditional backgrounds can be interpreted and incorporated into contemporary architecture through the coupled simulation of the historical architectural features with one another. Hence, it becomes possible to reflect the process of modernizing traditional architecture. Given that the organic, deformed massive glass facades with several traditional motifs have recently proliferated in the Middle East, it can be concluded that they do not reflect the modernization of traditional architecture since they simply imitate modernity with no obvious sources.

ICONARP – Volume 11, Issue 1 / Published: 27.06.2023

ACKNOWLEDGEMENTS/NOTES

The manuscript produced from a master's thesis of Motasem Issa Mahmoud Abu Zer: Eskişehir Osmangazi University, Graduate School of Natural and Applied Sciences, June 2022 with the title of "*Usage Modernizing in Conservation of Local Architectural Heritage: The Case of Amman in Jordan*".

REFERENCES

Abdelkader, R., and Park, J. H. (2017). The evolving transformation of mashrabiya as a traditional Middle Eastern architecture element. *International Journal of Civil and Environmental Engineering, 17*, 15-20.

Adam, R. (2008). Globalisation and architecture. *Architectural Review-London, 1332*, 74.

Al-Asad, M. (1995). *The muqarnas: A geometric analysis. In the Topkapi scroll–geometry and ornament in Islamic architecture by Gulru Necipoglu*. Santa Monica: The Getty Center for the History of Art and Humanities, 349-359.

Al-Kashi, G. A. (1427). *Miftah al-Hisab (key to arithmetics)*. Samarkand: Hand-Written.

Al-Kashi, G. A. (1960). *Miftah al-Hisab (key to arithmetics)*. Nader Nabulsi (ed.). Damascus: Damascus University.

Bachelard, G. (1994). *The Poetics of Space*. (originally 1958 in French), Boston MA: Beacon Press.

Bagader, M. A. A. (2016). *The Evolution of Built Heritage Conservation Policies in Saudi Arabia between 1970 and 2015: The Case of Historic Jeddah*. (Doctoral Dissertation). University of Manchester.

Barr, A. H., Hitchcock, H. R., & Johnson, P. (1995). *The International Style*. W.W. Norton and Company, London, p. 35.

Behiri, A. (2011). "Heritage rehabilitation in sustainable development policy for a better environment quality in small historical coastal cities: the case of Cherchell in Algeria". *International Conference on Green Buildings and Sustainable Cities*, 753- 759.

Bell, P., Green, T., Fisher, J., and Baum, A., (1996). *Environmental Psychology*. 4th edition, Harcourt Brace College Publishers, Fort Worth.

Bloom, J. M. (1988). The introduction of the *muqarnas* into Egypt. *Muqarnas: An Annual on Islamic Art and Architecture, 5* (1), 21-28.

Brockhoff, S., Krieger, T., & Meierrieks, D. (2015). Great expectations and hard times: The (nontrivial) impact of education on domestic terrorism. *Journal of Conflict Resolution, 59*(7), 1186-1215.

Carrillo, A. (2016). The Sasanian tradition in ʿAbbāsid Art: Squinch fragmentation as the structural origin of the *muqarnas*. *Mirabilia: Electronic Journal of Antiquity and Middle Ages, 22*, 201-226.

Castera, J. M. (2003). "Play with infinity. In *meeting Alhambra". ISAMA-BRIDGES Conference Proceedings*. University of Granada, 189-196.

Creswell, K. A. C. (1952). *The Muslim Architecture of Egypt*. Oxford: Clarendon Press.

Dadkhah, N., Safaeipour, H., and Memarian, G. (2012). *Traditional complex modularity in Islamic and Persian architecture: Interpretations in muqarnas and patkâné crafts, focusing on their prefabricated essence*. In Theory and Practice of Architectural Production. US: Temple University.

DoldSamplonius, Y. (1992). Practical Arabic mathematics: Measuring the *muqarnas* by al-Kashi. *Centaurus, 35*, 193-242.

DOI: 10.15320/ICONARP.2023.237

DoldSamplonius, Y., and Harmsen, S. L. (2005). The *muqarnas* plate found at Takht-I Sulayman: A new interpretation. *Muqarnas: An Annual on Islamic Art and Architecture, 22*, 85-94.

Flying Buttress (2022, December 5).
https://commons.wikimedia.org/wiki/File:Flying Buttress (PSF).png.

Frampton, K. (1993). "Toward a Critical Regionalism: Six points for an architecture of resistance". Postmodernism*, Routledge, 268.*

Hattstein, M., and Delius, P. (eds.) (2000). *Islam: Kunst und architektur*. Köln*:* Ullmann Publishing.

Graham, B. (2011). *Sharing space? Geography and politics in Post-conflict Northern Ireland, Cultural Memories: the geographical point of view*. London and New York: Springer Dordrecht Heidelberg.

Groat, L. N., and Wang, D. (2013). Architectural research methods *(2nd ed.). New Jersey: Wiley.*

Huerta Fernández, S. (2001). *Mechanics of masonry vaults: The equilibrium approach*. P.B. Lourenço, P. Roca (eds.). Historical Constructions. Guimarães.

Imani, E. (2017). *Historical and geometrical analysis of muqarnas and prospect of its reflection on today's architecture*. MS thesis, Middle East Technical University. Ankara, Turkey.

Intersecting arch (2022, December 5).
https://www.neh.gov/humanities/2009/marchapril/feature/thieves-pleasure).

Jokilehto, J. (2000). ICCROM's involvement in risk preparedness. *Journal of the American Institute for Conservation, 39*(1), 173-179.

Koolhaas, R., Mau, B., Sigler, J., & Werlemann, H. (1995). *Small, medium, large, extra-large: Office for Metropolitan Architecture.* New York NY: Monacelli Press.

Lang, J. T. (2002). *A concise history of modern architecture in India*. Hyderabad: Orient Blackswan.

Larkham, P. J. (1995). *Heritage as planned and conserved*. Tourism and society. In G.W. Shaw (Ed.). Tourism and Society. London: Manssell, 85-117.

Lefaivre, L., & Tzonis, A. (2012). *Architecture of regionalism in the age of globalization: Peaks and valleys in the flat world*. Routledge.

Li, H. (2017). "Daily Life in China: A Method of Modernizing Local Architecture and Localizing Modern Architecture". UIA 2017 Seoul World Architects Congress. Seoul.

Madanipour, A. (2003). *Public and private spaces of the city*. Routledge

Mashrabiya (2022, December 10). *https://*3docean*.net/item/islamic-window-mashrabiya/23430425*.

Maskin, A. Y. M. (2019). *Application of muqarnas in the modern world*. Doctoral Dissertation, Hamad Bin Khalifa University. Doha, Qatar.

Navickienė, E., Riaubienė, E. (2018). Changes of approach to urban context in international guidelines and experiences in Lithuanian urban environment. *Scientific Journal of Latvia University of Life Sciences and Technologies Landscape Architecture and Art*, *13* (13), 7-17.

Nikolinakou, M. K., Tallon, A. J., and Ochsendorf, J. A. (2005). Structure and form of early Gothic flying buttresses. *Revue Européenne de Génie Civil, 9* (9-10), 1191-1217.

Omer, S. (2011). Islamic architecture and the prospect of its revival today. *Journal of Architecture, Planning and Construction Management, 1* (1), 1-17.

Ouyang, F. X. (2016). "Discussion on Fusion Method of Tradition and Modernity in Architecture Design". *In 2016 5th International Conference on Civil, Architectural and Hydraulic Engineering (ICCAHE 2016)*. Atlantis Press.

Park, C., Allaby, M. (2017). *"Heritage". A Dictionary of Environment and Conservation (3 ed.*). Oxford University Press.

Shweder, R. A., Goodnow, J., Hatano, G., LeVine, H., Markus, H., & Miller, P. (1998). *The cultural psychology of development: One mind, many mentalities.* In W. Damon (Ed.), Handbook of child development. New York: Wiley, 865–937

Takahashi, S. (1973). Muqarnas: A three-dimensional decoration of Islam architecture. http://www.tamabi.ac.jp/idd/shiro/muqarnas/default.htm.

Takahashi, S. (1982). *Study of stalactite*. Tama Art University Bulletin I, 135-152.

Tabba, Y. (1985). The *muqarnas* dome: Its origin and meaning. *Muqarnas: An Annual on Islamic Art and Architecture, 3*, 61-74.

Turner, M., & Singer, R. (2015). "European Architectural Heritage and Conservation in the Levant–Parallels and Influences". *Monumenta, 3*, 448-456.

Tzonis, A. (2008). *Peak and Valleys (by Architecture) in a Flat (Digital) World*. Schriften der Bauhaus-Universität Weimar, Professur Theorie und Geschichte der modernen Architektur, 183-191.

Van den Hoeven, S., and Van der Veen, M. (2010). *Mathematics in Islamic Arts*. Utrecht University, Oudegracht, Netherland.

Verstrynge, E., Schueremans, L., and Smars, P. (2012). Controlled intervention: Monitoring the dismantlement and reconstruction of the flying buttresses of two Gothic churches. *International Journal of Architectural Heritage, 6* (6), 689-708.

Whiting, J. W., & Child, I. L. (1953). Child training and personality: a cross-cultural study

Yaghan, M. A. (1998). Structural genuine *muqarnas* dome: Definition, unit analysis, and a computer generation system. *Journal of King Saud University, Architecture and Planning, 10,* 17-52.

Resume

Motasem Issa Mahmoud Abu Zer got a Master's degree from the Department of Architecture at Eskişehir Osmangazi University in 2022 with the title of "Usage Modernizing in Conservation of Local Architectural Heritage: The Case of Amman in Jordan". He has a bachelor degree of Architectural Engineering at Hashemite University. He has interested with drawing skills to design buildings that are functional, safe and sustainable within cultural identity framework, cultural heritage, and also architectural restoration.

Kader Reyhan (Asst Prof. Dr.) is working at the Department of Architecture of Eskişehir Osmangazi University as head of Architectural Restoration program. He got a master's degree from the Architectural Restoration program in 2014 and a PhD degree from the Department of Architecture of İzmir Institute of Technology in 2011. He is interested in architectural heritage, architectural restoration, historical buildings, historical building types, historical construction techniques and materials.

DOI: 10.15320/ICONARP.2023.237