

PROPORTIONS AND HUMAN SCALE IN DAMASCENE COURTYARD HOUSES

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Abstract

Interior designers, architects, landscape architects, and even urban designers, agree that environment, as a form of non-verbal communication means, has a symbolic dimension to it. As for its aesthetic dimension, it seems that beauty is related to a certain proportion, partially and as a whole. Suitable proportion leaves a good impression upon the beholders, especially when it matches human proportion. That in fact was the underlining belief of LeCorbusier, according to which he developed his Modular concept.

The study searches for a modular, or proportion, system that governs the design of Damascene traditional house. By geometrical and mathematical examinations of 28 traditional houses, it was found that a certain proportional relationship existed; however, these proportional relationships were not fixed ones. The study relied on analyzing the Iwan elevation as well as the inner courtyard proportion in relation to the building area. Charts, diagrams and tables were produced to summarize the results.

Keywords

Proportion; human scale, traditional architecture; Damascus; courtyard houses.

Introduction

All over the world, there are plenty of evidences of adapting common systems to produce different traditional buildings that architecturally signify various functions in response to users' needs and cultural background. As a human fine product, buildings can not only be looked at as places that fulfill certain functions or genuinely designed to harmoniously fill a spatial gap within the urban fabric, but it is also a form, geometrically speaking, that visually pleases the beholder and psychologically effects his/her mental and emotional status. Architecture serves multi-purposes. The concern in this study, however, is the presence, more or less, of humanistic aspects in architecture. Built environment in Muslim areas is the subject of the study.

The question forwarded in this research is whether there are geometrical aspects that play a role in composing architecture in the Islamic world. A case study is taken in relation to the Damascene house to show that there are systems of proportion that govern the composition of architectural components.

Steps followed to reach the goal of the study are as follows: a literature review related to the topic was done first; then 28 plans of traditional houses were examined to analyze the proportional relations among their different spaces, especially the inner courtyard, *lawn* elevation, and the house built area. The analysis concerns the examination of the parts with regard to each other. Thirdly, with similar number of house cases, another search for proportion was done on area measurement of the inner courtyard and the house as a whole. The result was a set of proportions that was responsible for the building appearance (entire and complete body), wherein each member agrees with the others.

Theories of Proportions

The study of proportion (geometric, arithmetic, and harmonic) is as old perhaps as architecture. In fact, all of these studies form an attempt to define beauty in architecture, or to search for aspects responsible of different feelings within different built environments. "Among the Cistercians, Gothic, Renaissance, Egyptian, Semitic, Babylonian, Arab, Greek and Roman traditions, the harmonic proportions, human proportions, cosmological/ astronomical proportions and orientations, and various aspects of sacred geometry (the vesica piscis), pentagram, golden ratio, and small whole-number ratios) were all applied as part of the practice of architectural design".¹

Nader Ardalan and Laleh Bakhtiar offered in their new edition of "The Sense of Unity" the geometric shapes in nature showing laws of similitude, symmetry, and geometry (p.21). As a result, they argued that "resting on an

objective foundation, independent of man and his subjective tastes, a beauty is attained that which is general, universal, and eternal. Order and proportion are viewed as cosmic laws whose processes man undertakes to comprehend through arithmetic, geometry, and harmony" (Ardalan and Bakhtiar, 2000, p. 21). The arithmetical proportions of Roman Architectural distinctionly presented in Andrea Palladio's book "The Four Books of Architecture" (The book is written in 1400-latest edition 2002). In more details Wittkower's book "Architectural Principles in the age of Humanism" (3rd rev.ed.1998) is a good reference. On an international scale, Fitcher's book The History of Architecture (20th edition, 1998) discussed, with the aid of a number of drawings, the dominating proportional types that govern the design of buildings. Although, scientifically presented in a traditional way, it unarguably underlines the difference among traditional buildings all around the world. The following are some of the most known theories that form the base for architectural proportion in different regions.

The Golden Section: It is known as the proportion between two portions of a line being divided according to the formula $(a/b = b/a+b = 1.618)$ or $(3/5 = 5/8 = 8/13)$. When similar formula is applied on both lengths of rectangular sides (ab and bc), it is called "Golden Rectangle". Also, The Golden Section is defined as the value of each number as a result of the proceeding two numbers, that is (1,2,3,5,8,13,etc.), forming a series that is similar to the Fibonacci Series in Mathematics. The initiation of the Golden Section refers to the Ancient Greek. At that time, Pythagoras developed his concept, which stated the relation between some harmonic numbers and the universe. Greek

believed that human body and temples were related to Higher Universal Order. They noticed the accordance of the Golden Section System with the proportion of human body. As a result, their buildings were designed on the bases of The Golden Section. Similarly, Gothic Architects followed their footsteps. (Figure 1).

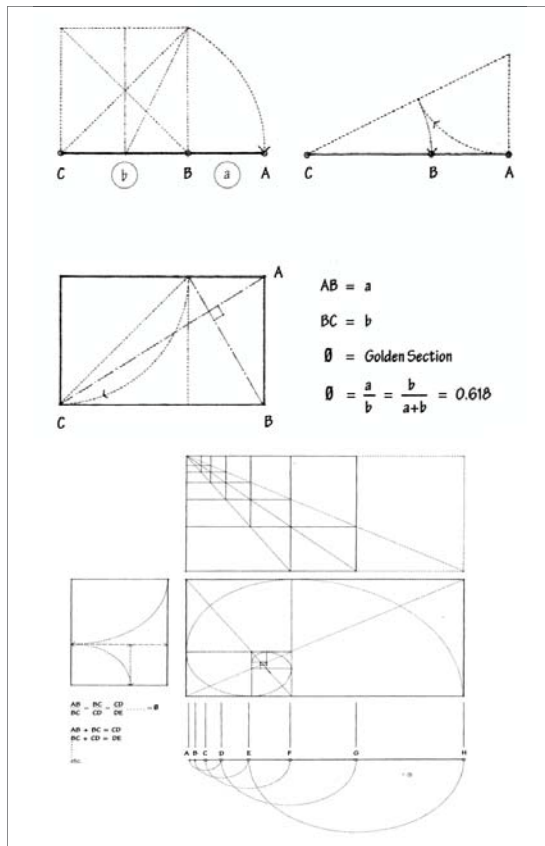


Figure 1: The Golden Section (Source: D. K. Ching, 1996).

The Orders: The term "orders" refers to the Greek and Roman Columns that appears in their temples and buildings. The unit of measurement was the radius of column section. It was their Module where 12 units formed the height of the Tuscan column and the Doric, and 18 units formed the height of the Ionic, Corinthian and Composite column in the Roman style. From that Module, all architectural details were calculated, as the complete structure contains the Entablature, Shaft, and Pedestal.

Renaissance Theories: Designers during the Renaissance era relied on Pythagoras' proportion theory. He considered the five-head-star as a spiritual and holy symbol. Starting from a pentagon, he extended all sides to meet forming a five-head-star. When drawing a line between every two close consecutive heads, a bigger pentagon was produced. Repeating the extension of the star's sides and the connecting lines, a series of stars and pentagons were produced. Fitholrs found that the proportion of each star's sides and the pentagon sides was similar to that of the Golden Section. Also, the proportion of all numbers respectively with the series of star and pentagon is similar to that of the Golden Section Series. (Figure 2)

The Modular: Le Corbusier, a well-known architect of the twentieth century, had two attempts to search for a module that helps achieve both the beauty and functional aspects of architecture. He did his first attempt by taking the average height of 175 French man as a base. He applied the Golden Section division on this height. He obtained the number 108 cm, which reaches the human belly. This height reminds of the belly height of the ideal man who was drawn by Leonardo De vinci. Le

Corbusier divided the number 108 to smaller units in accordance with The Golden Section division. Being unconvinced by the resulting numbers, beside his fearing of the production of small rooms, low ceiling heights, and unsuitable door way height, he carried out a second attempt by using the height of a 180 cm English Policeman. Repeating similar calculations, he ended up with two final series of numbers that gave a variety of options. In an illustrative drawing, he shows the vision of the application of these numbers starting from the feet, to carrying out different functions, such as table, desk, chair, counter, and doorway. (Figure 3).

The Ken: It is the Japanese measurement unit used for organizing interior and exterior architectural elements.¹ For example, the placement of columns determines the size of the panels that form their interior and exterior light partitions. The usual height of columns is 1 *Ken*, while the distance between columns is equal to 3 or 3 ½ *ken*. This distance is divided to accommodate four panels (*fusuma*)², the desirable proportion in Japan. Another example that usually determines the structural modular and wall panels as well is the mat. It is called *Tatami*. It is 2 1/8 inches in thickness, 6 feet in length, and 3 feet in width. The number of mats covering Japanese space determines the dimensions of rooms. In fact, one can describe the room by the mats' pattern. Mats are arranged in different patterns corresponding to the desired functions of the room. Generally the size is based on 4 ½, 6, 8, 12, 15 and 18 mat combinations. (Figure 4)

So, there is a number of theories applied in different parts of the world and at different times. All prove the importance of proportion

spiritually and physically, beside the need to create pleasant and beautiful architecture. What about Islamic Architecture?

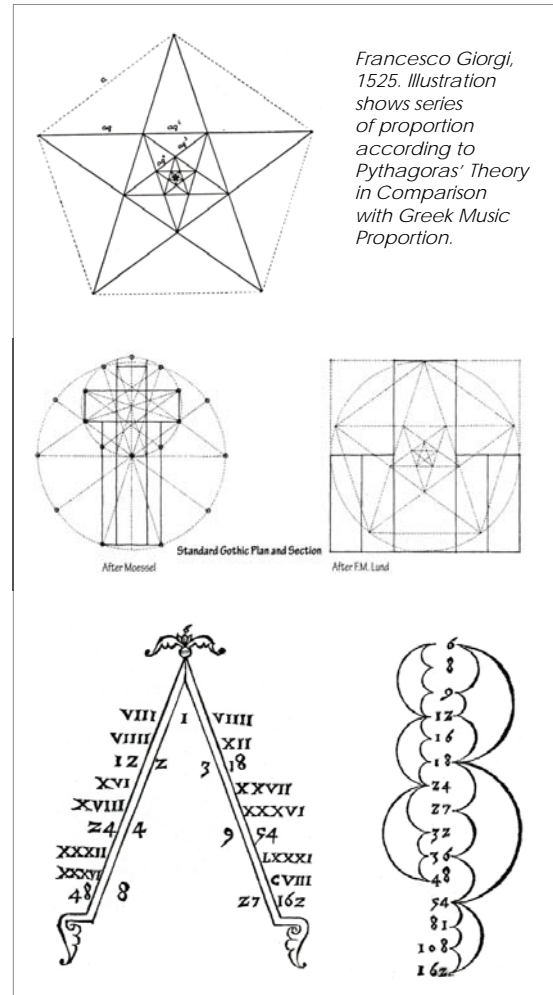


Figure 2: Renaissance Theories (Source: D. K. Ching, 1996).

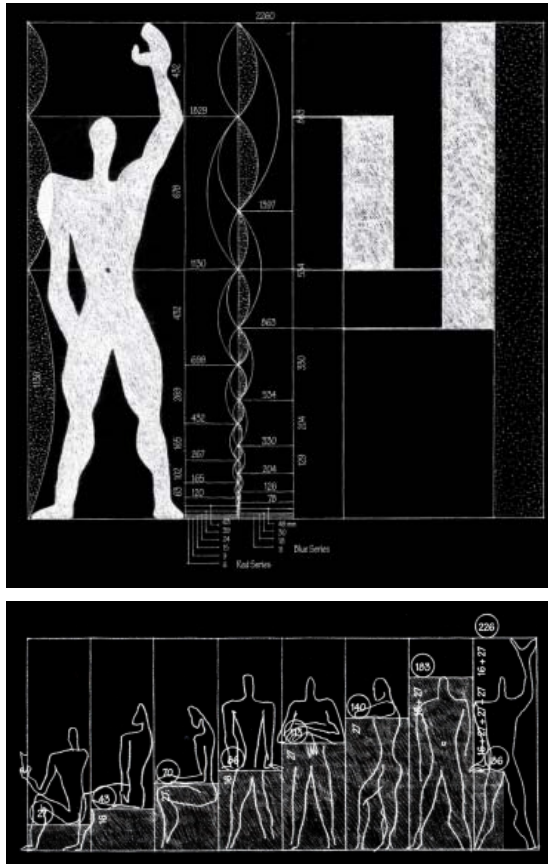


Figure 3: The Modular: LeCorbusier's concept. (Source: D. K. Ching, 1996).

In his article: "Omar Khayyam and the Artesian", Ozdural (1995) proves the existence of Converzaioni, where the willingness of Muslim Mathematicians to cooperate with artisans to solves problems regarding geometry and architecture. This article did not show if such collaboration had prolonged to the building

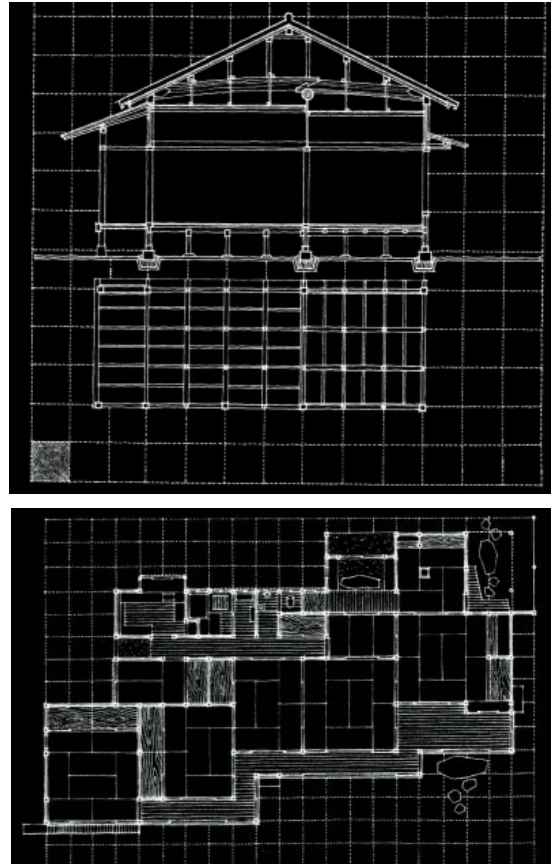


Figure 4: The Ken as a measurement unit used in a typical Japanese house. (Source: D. K. Ching, 1996).

plans. But working on the architectural dimension whether in elevations or plans is demonstrated in other references such as Dodds (1992) and Rasmussen (1964) who illustrate several examples where building plans are proportionally thought-out. Likewise, in pages 126 and 127 of their book "Geometric

Concepts in Islamic Art", Issam El-Said and Ayse Parman (1988) illustrate six Islamic monuments' plans (such as Al-Mshatta and Qasr Al-Kharnah) where their architectural design concepts followed geometric patterns that helped to develop the analysis of the section "The Square Courtyard" below. The following is an empirical study to find out about the existence of dimensional and geometrical proportions in typical residences of traditional neighborhoods inside the Walled City of Damascus.

Description of Damascene House

The Traditional Damascene built environment consists of organically connected buildings, share walls, or contiguous independent walls bound together by a system of private and public routes that limits interference with household privacy and maximizes social interaction. This traditional house is developed with respect to time and social rules. It consists of two floors, the ground floor is used for day activities as it contains the guest room, the living room, the kitchen, the Ka'a (a principle guest room), and the inner courtyard. The inner courtyard has several components, these are: fountain, trees, plants, and sky. The *Iwan* is a covered part of the courtyard located at its northern side. The courtyard symbolically represents the Garden of Eden described in the Quran (The Muslim scripture book). Both the courtyard and the *Iwan* are used as one open-living area during the summer. They are found as a result of three directional factors: the socio-religious factor (determined in man-woman interaction with strangers), exposure to sun (four walls of the courtyard facades are exposed to sun), and the scenery (inward openings onto inner courtyard). These are the

essential features in the traditional house. The study will concentrate on their proportional qualities. The following two sections analyze the main interior facade of the courtyard that is the *Iwan* elevation and then explain geometrically the proportional relationship between the courtyard area and the house.

In order to select the samples for the geometrical analyses, some conditions are put forward. These are:

- 1- The house should be original, has no change or additional space(s).
- 2- There should be an *Iwan*.
- 3- The shape of the inner courtyard should be square or rectangular.

An additional condition was considered in the last section, that is the existence of a single inner courtyard only. The exclusion of houses containing other forms of inner courtyard and has more than one courtyard does not mean they lack originality. However, working on simple and most common forms helps simplify the matter and give a case for a future study of more complicated house designs that assumingly did not take their shapes coincidentally.

Dimensional Analysis of the Iwans' Facades

Searching for the presentation of proportions in historical buildings is done typically by applying geometrical or mathematical approaches on a single building, mostly one that carries significant function, such as a monument, palace or temple. Consequently, the results are confined to the case study. In this research the attempt

is different. The study searches for the common proportion presented in a number of different house sizes. Therefore, 28 houses are presented to study the *Iwan* elevation (opening, type, and

proportion). All *Iwan*'s dimensions are measured and a table below summarizes the calculations. (Figure 5 and Table 1 and 2).

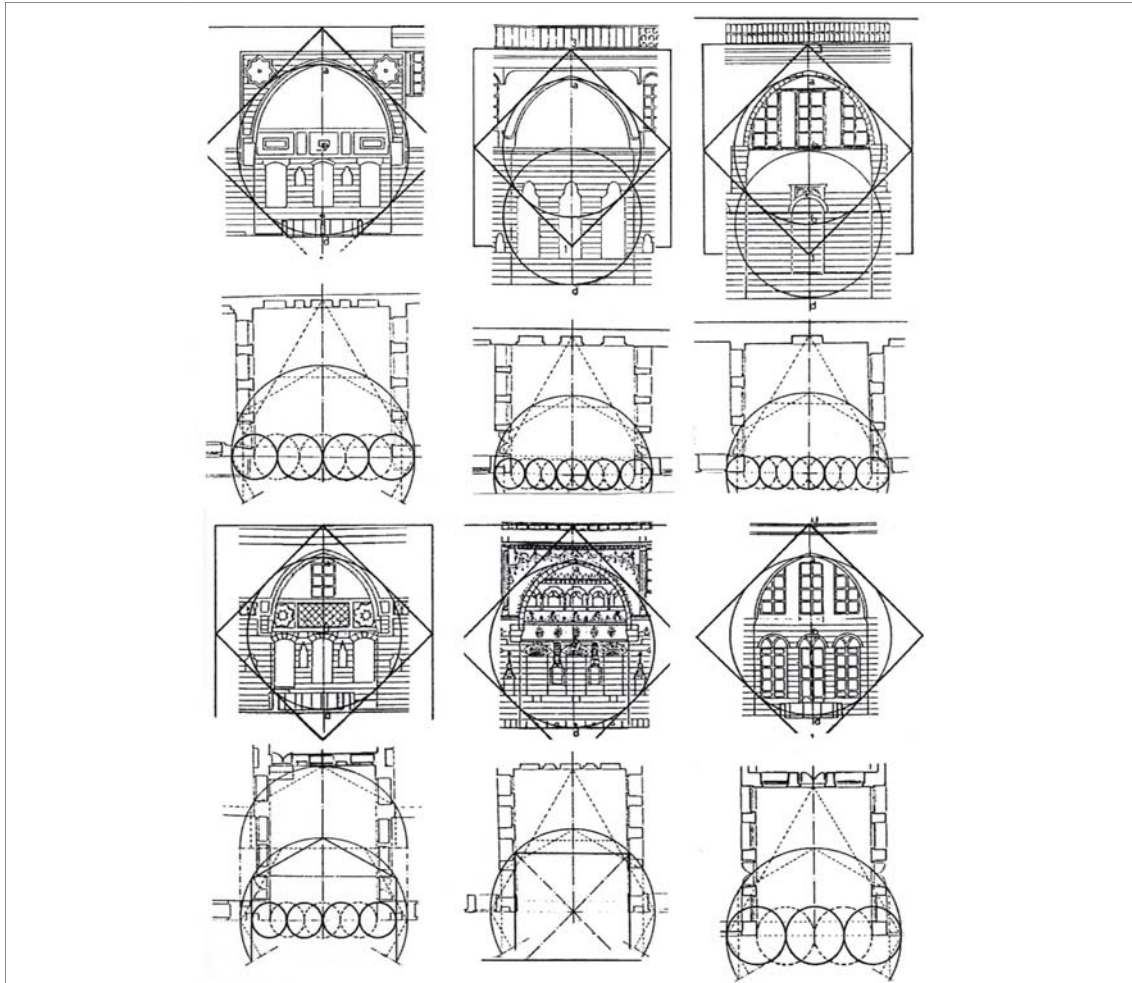
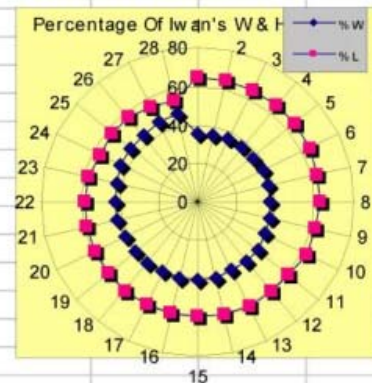
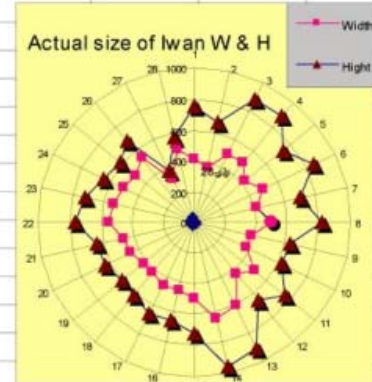


Figure 5: Six examples of the 28 houses being analysed: 1-Nezam House, 2-Alkowatly House, 3-Alswaid (alJazaari house), 4 Farahi Almoalem House, 5-Aljazari House(1), and 6-Alkazi House. (Source: Authors).

Table 1: Mathematical measurements of Iwans' elements for 28 traditional houses. (Source: Authors).

اسم المنزل أو المالك	Houe's Name	S No.	Width	Height	Base	W/H	% W	% L
الشاش	Alshash	1	410	750	490	0.55	35	65
الرحولة	Alrojoulh	2	370	670	440	0.55	36	64
الحصني	Alhasni	3	490	880	590	0.56	36	64
سويد الجزائري	Alswaid Alja.	4	490	880	615	0.56	36	64
عمر باشا الموصلني	Moseli	5	420	730	490	0.58	37	63
العليكي	Albalabki	6	490	850	420	0.58	37	63
سقا أميني	Saka-amini	7	410	700	380	0.59	37	63
القوتلي	Alkowatly	8	490	820	550	0.60	37	63
الحلبي	Alhalabi	9	375	620	380	0.60	38	62
أبو رباح	AbouRabah	10	380	620	400	0.61	38	62
مردم بك	MardamBek	11	490	750	480	0.65	40	60
الشريجي	Alshrbaji	12	425	650	360	0.65	40	60
جبري	Jabri	13	600	910	630	0.66	40	60
اليوسف	Alyousaf	14	640	960	610	0.67	40	60
ليزبونا	Lizbona	15	490	720	330	0.68	40	60
عبد القادر الجزائري	AbadAlkader	16	450	660	380	0.68	41	59
الجزائري 1	Aljazaari 1	17	450	660	415	0.68	41	59
فارحي المعلم 2	Farhi 2	18	420	610	360	0.69	41	59
بولاد	Boulad	19	420	590	430	0.71	42	58
المهاني	Almahaini	20	450	630	280	0.71	42	58
الغزي 1	Alkazai	21	460	640	400	0.72	42	58
الدادا	Aldada	22	550	760	450	0.72	42	58
الشاري	Alshawi	23	525	725	420	0.72	42	58
سويد	Alswaid 2	24	510	650	370	0.78	44	56
فارحي المعلم 1	Farhi 1	25	480	610	330	0.79	44	56
نظام	Nizam	26	540	680	380	0.79	44	56
الغزي 2	Alkazai 2	27	310	370	200	0.84	46	54
صوان	Sawan	28	480	560	300	0.86	46	54
					mean	0.67		



Findings

Finding 1:

Considering the opening in the northern façade, measurements were as follows: the height of the opening was measured from the

arch pinnacle down to the floor level, and its width from wall to wall. The numerical finding is shown in table 1 with two charts that summarize the results of each *Iwan*. The first chart shows the actual measurements. It gives an understanding of the differences in sizes of *Iwan*

openings. For more a meaningful comparative look, the percentage of the height (H) and of the width (W) for each case are calculated. The results are represented in the second chart. It is noticeable that the common proportion of the opening of the façade's width and height is 40 and 60 respectively. This proportion is similar to the proportion of 2 to 3, which is presented in the literature reviews in the Golden Section series.

Finding 2:

As shown in table 2, there are 25 cases that have pointed arches, 3 of them have their centers located above the arch base. Beside the 25 cases, there are other three cases that have semi-circle arches. In order to analyze the proportion of each case and compare it with the others, two regular forms are adopted, the pentagon-based arch and the semi-circle arch. According to Pythagoras' concept, as mentioned in the literature review, the pentagon forms an important proportional element that has spiritual and physical symbols and beauty (for Europeans).

To construct a regular pointed arch, which requires two centers, a pentagon should be placed on one of its sides vertically, (let's say A and B), giving the shape of an arrowhead pointed upward. From both ends of the pentagon base side (A and B), two arches can be constructed starting from point A with a radius of AD or its equivalence AC, and another arch from the point B with a radius of BD or its equivalence BE. Whatever the size of the pentagon, the calculated proportion of the height to the width is always 0.69. Similarly, the calculation of the height and width of a semi-circular arch gives the proportion of 0.5. (Figure 6).

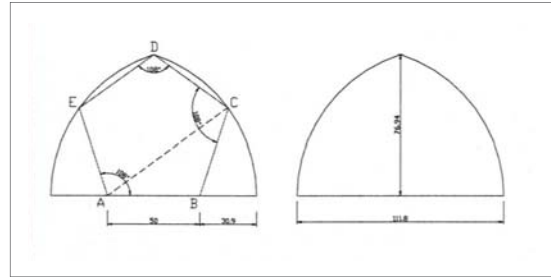


Figure 6: The construction of regular pointed arch. (Source: Authors).

To find out how close or far each case is from the regular pointed arch or semi-circle arch, few calculations are needed to determine the height and width of each arch of the 28 cases. The results are summarized in Table 2 with three attached charts. Presenting the actual measurement, the first chart shows the variety of arch sizes of all cases. The result of calculating the percentages of the width (W) and height (H) of each arch is presented in the second chart. The significant finding of chart 2 is that 24 cases have the proportion of H/W equals to 60 to 40, a result which recalls the Golden Section proportion of 3 to 2.

Finding 3:

The results of dividing the height over the width for each case help compare each case on a leaner scale to see how close or far each case is to the pentagon-based arch or the semi-circle arch (see Figure 7). It is noticeable that the proportional values are distributed linearly, no clear clustering is determined; thus, there is no agreeable proportion of all cases. However, the dominating proportion of H/W is ranging between 55 and 65. On one hand, four cases are similar to the pentagon-based

arch proportion; on the other hand, there are no actual semi-circle arches, even though three arches are marked as semi-circular. This is probably due to the location of their centers above or below their baseline, or as a result of the lack of accuracy during construction.

Table 2: Mathematical measurements of iwans' arches for 28 traditional houses. (Source: Authors).

	Arch								
Owners	S No.	Width	Hight	H/W	Type	% W	% L		
Boulad	1	380	160	0.42	circle	70	30		
Alkazi 2	2	310	170	0.55	pointed	65	35		
Alswaid Alj	3	480	265	0.55	pointed	64	36		
Alkazi 1	4	430	240	0.56	pointed	64	36		
Aljabri	5	500	280	0.56	pointed	64	36		
Nizam	6	530	300	0.57	pointed	64	36		
Moseli	7	420	240	0.57	pointed	64	36		
Saw an	8	450	260	0.58	pointed	63	37		
AbouRabah	9	380	220	0.58	pointed	63	37		
Mardanbek	10	465	270	0.58	pointed	63	37		
Alshawi	11	520	305	0.59	pointed	63	37		
Aljazaari 1	12	415	245	0.59	pointed	63	37		
Aldada	13	520	310	0.60	pointed	63	37		
Alyousaf	14	585	350	0.60	pointed	63	37		
Lizbona	15	500	300	0.60	circle	63	38		
Alswaid 2	16	460	280	0.61	pointed	62	38		
AbadAlkade	17	450	280	0.62	circle	62	38		
Farhi 1	18	450	280	0.62	pointed	62	38		
Alhasni	19	460	290	0.63	pointed	61	39		
Alhalabi	20	370	240	0.65	pointed	61	39		
Alkowatly	21	415	270	0.65	pointed	61	39		
Alrojoulh	22	340	230	0.68	pointed	60	40		
Alshrbaji	23	425	290	0.68	pointed	59	41		
Alshash	24	375	260	0.69	pointed	59	41		
Farhi2	25	360	250	0.69	pointed	59	41		
Saka-amini	26	430	320	0.74	pointed@	57	43		
Almahaini	27	470	350	0.74	pointed*	57	43		
Albalabki	28	460	430	0.93	pointed#	52	48		
					Mean				

Notes: * center above base 55 cm @ center above base 30 cm # center above base 65 cm

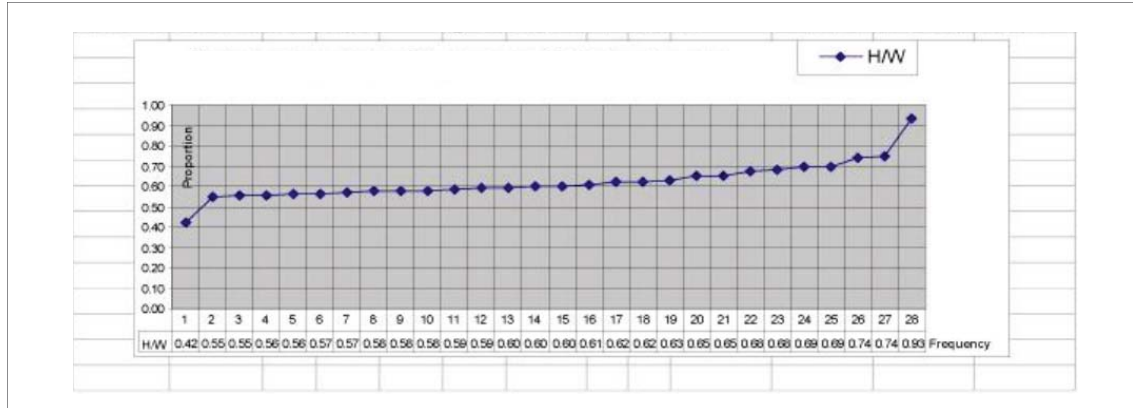


Figure 7: Frequency of proportions of H/W for all cases. (Source: Authors).

Geometrical Analysis

The aim of this analysis is to study the area of the house and its courtyard in order to search for proportions that dominate their dimensions. First, the proportions of square courtyards will be examined, then those of rectangular courtyards. Two questions are forwarded: 1- How can the size of the square/rectangular courtyard be determined? 2- Is there a proportional relation between the courtyard and the house area? To answer both questions, several examples are geometrically analyzed, starting with the search of the size of the courtyard. After going through many attempts to find out a meaningful geometrical relation between the inner courtyard and the house pattern, the following methods are reached leading to three types of the square courtyard and five types of the rectangular one. (Figure 8 and 9)

The Square Courtyard

To carry out the geometrical analysis on a traditional house with a square courtyard,

firstly, the square center is defined. Secondly, one draws a circle from that center with a radius reaching the furthestmost point of the house. Thirdly, one confines this circle with two squares, their sides tangible to the circle, with a 45-degree-angle difference between them forming an octagon. From the intersections that occurred between each square's diameter and the other square's sides, one obtains five squares hierarchically reduced in size toward the center with a certain proportion. In this case, one can determine the sides of the courtyard. Its location has three possibilities, either on the first square or the second or the third, counting from the center. The inner courtyard can not be smaller or bigger than these three squares (Figure 8).

The Rectangular Inner Courtyard

In the geometrical analyses, the determination of the lengths of a rectangular courtyard's sides forms the starting point. There are five methods, each of which represents one proportional type of the courtyard, two of which will be explained here, while the other three will be illustrated

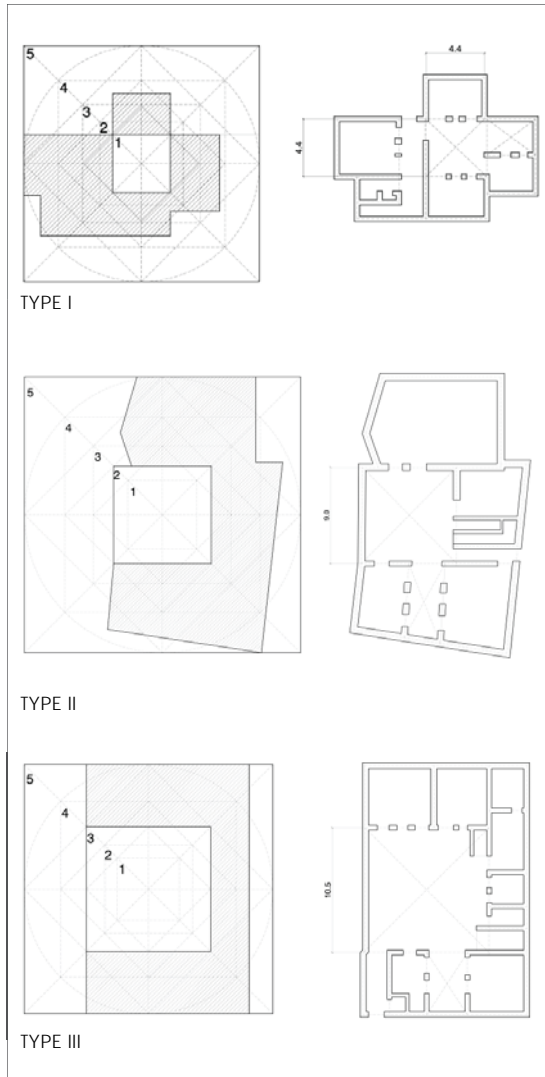


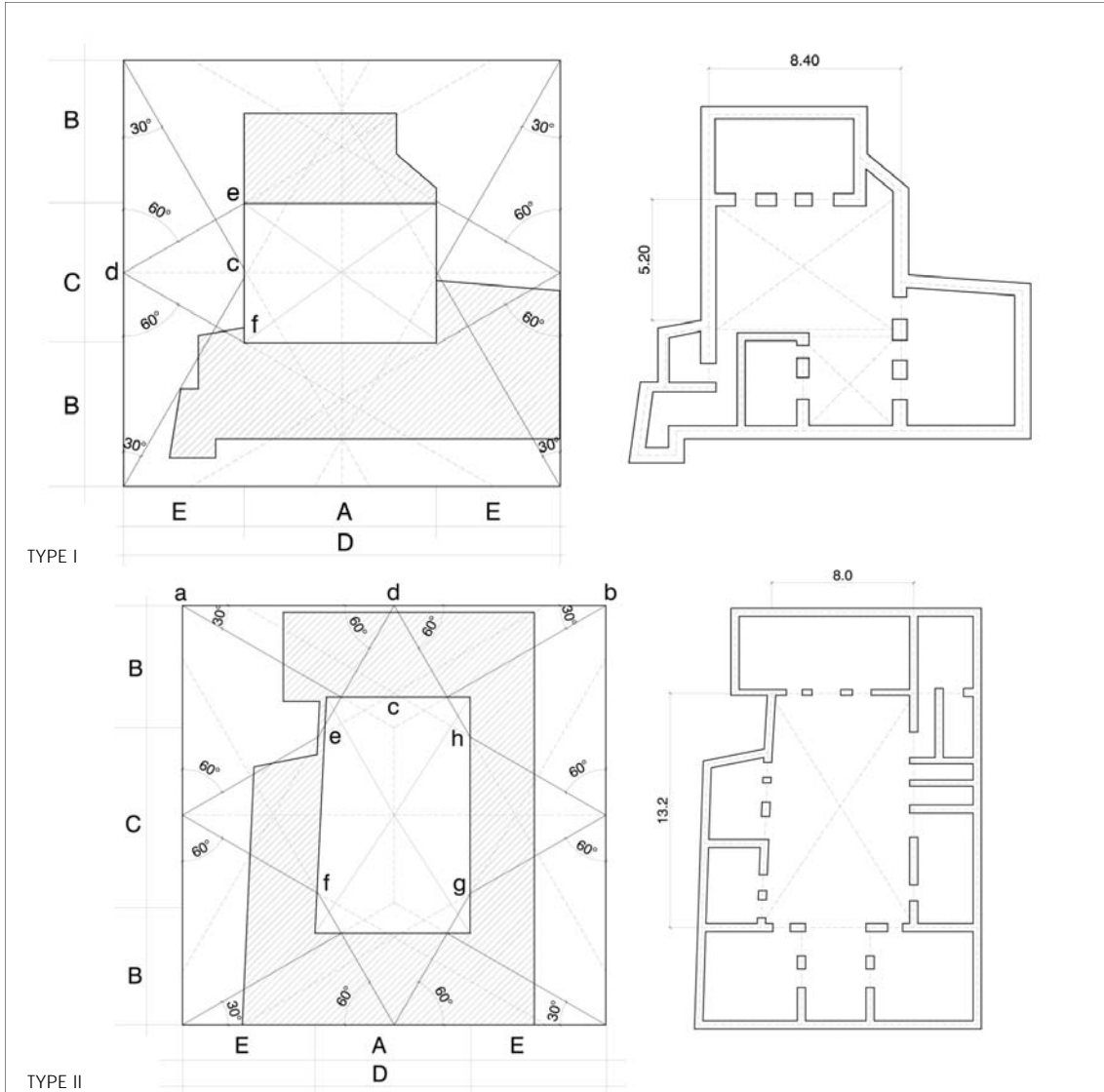
Figure 8: Three types of square courtyard houses. (Source: Authors).

only, as they would be self-explanatory.

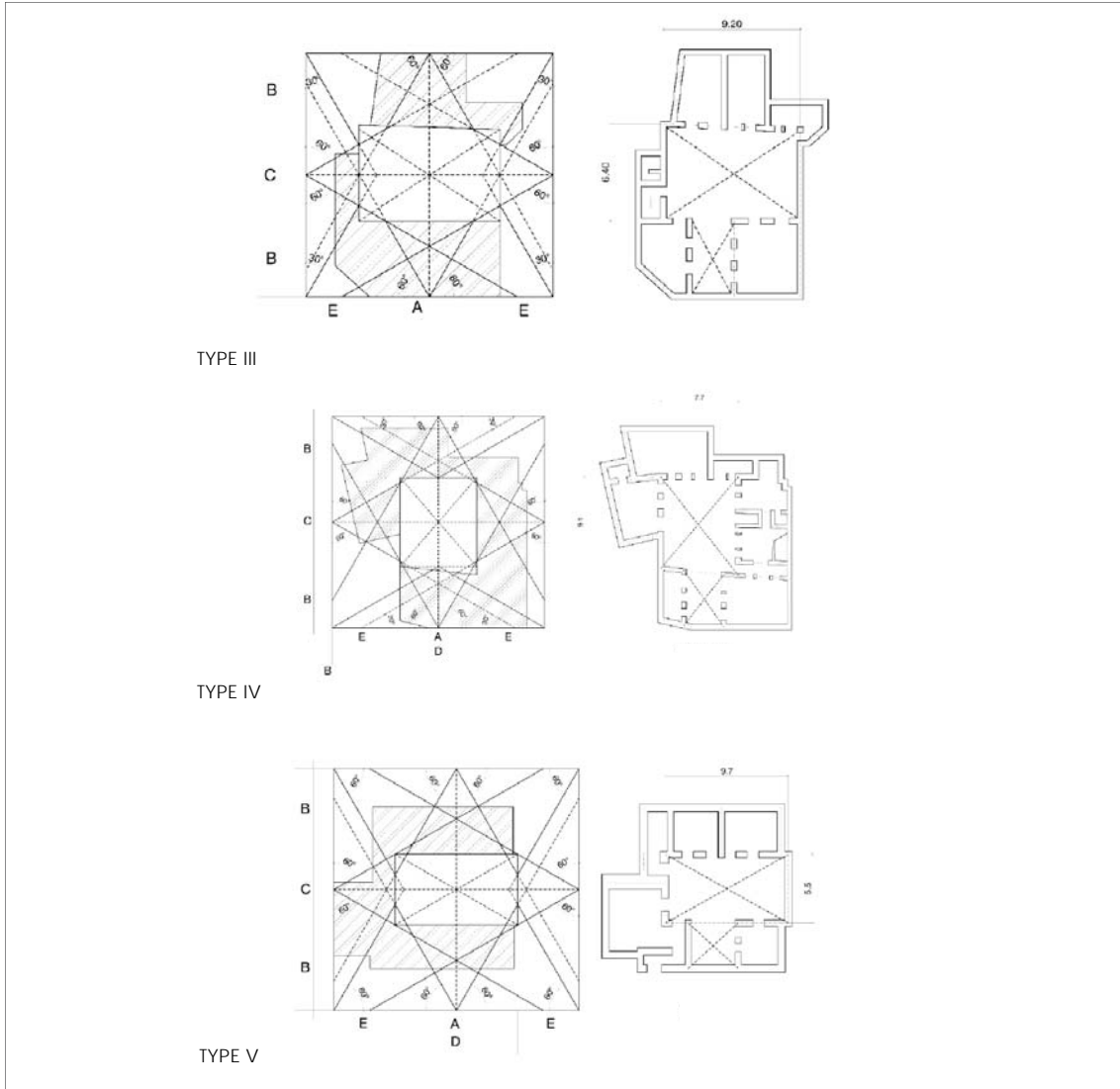
Type I: One starts with drawing two 30-degree-angle lines, one line from the corner (a) of the bordering square, and the other from the opposite corner (b). Both lines will intersect in point (c). This intersection represents the center of the short side (see Illustration 9). From the midpoint (d) of the side (ab), one draws two lines with 60-degree-angle. Each line will intersect with the vertical line drawn from point (d) determining the length of one end of the short side (e and f). By carrying the same procedure of the top side of the Boundary Square, one obtains the location of the other short side. By connecting both side ends one reaches the final rectangle, which has the proportion of 1:4. (Figure 9).

Type II: The second case has also a few steps to draw. The first is similar to the first step presented in the previous case, while the second step requires drawing 60-degree-angle lines from all midpoint sides of the boundary square, every two angles will intersect in (d, e, f, g) forming all together a four-head star (Figure 10). The third step requires drawing two lines (de and fg). When extending both lines, they will intersect with the vertical line drawn from point (c) and form its mirror point (c'). The result is a rectangle with the proportion of 1:2. (Figure 10).

Three other types (III, IV, and V) result from a manipulation in the intersections among the 30- and 60-degree-angle lines. The results are three rectangles with different proportions; these are: 1.6, 1.3, and 1.2. The first proportion recalls The Golden Rectangle, whose proportion is equal to 1.618. (Figures 11, 12, 13).



Figures 9 -10: Rectangular courtyard house types I and II. (Source: Authors).



Figures 10,11,12: Rectangular courtyard house types III, IV, and V. (Source: Authors).

Conclusion

Unlike other cultures, there is not a fixed proportion governing the traditional Damascene architectural elements partially (the case of the *Iwan*) and as a whole (the case of inner courtyard and house size). In other words, there are no proportional constraints in the house design. It is flexible as different cases may require different proportions, or a range of proportions. That does not mean the resulted architecture is fallen within a case of uncertainty, but rather it is a response to different perception that people usually have and to different standards

of beauty that vary among peoples within the same society. The result is an inter-subjective one; it is summed up in Table 3.

In applying the results, one can design a new house with reference to the geometrical relationships discovered in the Damascene house without copying it. Regarding the house part elements, such as windows or doors, one can find a use out of the mathematical considerations that were found in the *Iwan* openings and arches, keeping in mind that the pointed arch was the most preferred type.

Table 3: Proportions governing traditional Damascene houses. (Source: Authors).

* IWAN				Square Courtyard/Square Boundary			Rectangular Courtyard					
Opening		Arch		Square 1	Square 2	Square 3		Type I	Type I	Type I	Type I	Type I
W	H	W	H	1/4	1/2.7	1/2	**	1/5	1/5	1/7	1/6	1/6
40	60	40	60				***	1.6	1.4	1.3	1.2	2
* The figures here are relative and not absolute ** The proportion of the courtyard area to the boundary square *** The proportion of the long side and short side of the courtyard												

If we agree that proportion is not only spatially conceived, we will extend the study to find out the proportional existence of solid and void, empty and full, earth and heaven, symbolically poor and rich, inside and outside, climate / sun / environment etc., which is important to understand the esthetical and spiritual values of the whole.^[1] Additionally, the study of proportion may consider the psychological side of the users (Abas, S. Jan 2004) or the harmonic sceneries of the traditional cities, as Hall puts it: "There was a time in our past when one could walk down any street and be surrounded by

harmonious buildings. Such a street wasn't perfect..., but it was alive. The old buildings smiled, while our new buildings are faceless. The old buildings sang, while the buildings of our age have no music in them". (HALE 1994, 1; cited in Langhein 2005).

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Useful websites

http://en.wikipedia.org/wiki/Fibonacci_number
http://en.wikipedia.org/wiki/Le_Corbusier
<http://www.emis.de/Journals/NNJ/Didactics-RHF.html>
http://www.metmuseum.org/explore/publications/pdfs/islamic_geometric/islamic_art_and_geometric_design.pdf
<http://milan.milanovic.org/math/english/golden/golden4.html>

Notes


¹ [http://en.wikipedia.org/wiki/Proportion_\(architecture\)](http://en.wikipedia.org/wiki/Proportion_(architecture))

² Ken is a measurement unit that is equal to ten shaku, which measure 11.93 inches. Shaku itself constitutes of 10 sun, the basic measurement unit.

³ Fusuma: Interior partition, which can be completely removed to convert the many rooms into one open space. Fusuma is covered with heavy, opaque paper on both sides. Their other form of the panel is called shoji. It consists of thin wooden grid with a protecting plate at the base. On the outer face, translucent paper is pasted.

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