Université de Montréal

Enhancing Well-Being in Iranian Residential Dwellings by Exploring Traditional Techniques for Using Daylight in Iranian Courtyard Houses

Améliorer le bien-être dans les logements résidentiels iraniens en explorant les techniques traditionnelles de l'utilisation de la lumière du jour dans les maisons à cour iraniennes

par
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Tiiu Poldma, directrice de recherche

Philippe Lalande, président rapporteur

Giovanni De Paoli, membre du jury

Résumé

Dans les dernières décennies, les changements morphologiques des maisons iraniennes, l'arrivage de l'éclairage artificiel et le manque de connaissances suffisants de la valeur de la lumière du jour pour le bien-être des occupants ont résulté une diminution de l'utilisation de la lumière du jour dans les habitations iraniennes contemporaines. En conséquence, le niveau du bien-être des occupants a décru ce qui peut être corrélée avec la diminution de l'utilisation de la lumière du jour. Considérant l'architecture traditionnelle iranienne et l'importance de la lumière du jour dans les habitations traditionnelles, cette recherche étudie l'utilisation de la lumière du jour dans les habitations traditionnelles et explore comment extrapoler ces techniques dans les maisons contemporaines pourrait augmenter l'utilisation de la lumière du jour et par conséquence améliorer le bien-être des occupants.

Une revue de littérature, une enquête des experts iraniens et une étude de cas des maisons à cour traditionnelles à la ville de Kashan ont permis de recueillir les données nécessaires pour cette recherche. De par le contexte de recherche, la ville de Kashan a été choisie particulièrement grâce à sa texture historique intacte. L'analyse de la lumière du jour a été faite par un logiciel de simulation pour trois maisons à cour de la ville de Kashan ayant les mêmes caractéristiques de salon d'hiver. Cette étude se concentre sur l'analyse de la lumière du jour dans les salons d'hiver du fait de la priorité obtenue de l'enquête des experts et de la revue de littérature.

Les résultats de cette recherche montrent que l'extrapolation des techniques traditionnelles de l'utilisation de lumière du jour dans les habitations modernes peut être considérée comme une option de conception alternative.

Cette dernière peut optimiser l'utilisation de lumière du jour et par conséquence améliorer le bien-être des occupants. L'approche utilisée dans cette recherche a fourni une occasion d’étudier l'architecture du passé et d’évaluer plus précisément son importance. Cette recherche contribue ainsi à définir un modèle en tirant les leçons du passé pour résoudre les problèmes actuels.

Mots-clés : logement, maison, lumière du jour, lumière naturelle, maison traditionnelle iranienne, maison contemporaine iranienne, la simulation de lumière du jour par ordinateur.

Abstract

In the past several decades, the morphological changes of Iranian houses, the advent of artificial lighting and the lack of knowledge about the value of daylight on occupants' well-being have caused a decrease in the use of daylight in contemporary Iranian dwellings. As a consequence, there was a reduction in occupants' well-being that may be correlated with the reduced use of daylight. Considering Iranian traditional architecture and the significance of daylight in traditional dwellings, this research has studied using daylight in traditional dwellings and has explored how extrapolating these techniques into contemporary houses might increase the use of daylight and consequently to enhance occupants' well-being.

The required data for this research were collected through literature review, the survey of Iranian experts and the case study of traditional courtyard houses in Kashan city. Kashan city was selected as the context of this research mainly because of its pure historic texture. Amongst the traditional courtyards of Kashan city, three traditional courtyard houses were chosen according to the same features of their winter living rooms and analyzed by daylight simulation software in the worst-case design scenario. The winter living rooms were selected as the focus area based on the extracted results of the survey of Iranian experts and literature review.

According to the results that were extracted from this research, it was clarified that extrapolating the traditional techniques of using daylight into modern dwellings can be considered as a design option to optimize the use of daylight and as a result to enhance occupants' well-being. The approach utilized in this research has provided an opportunity for studying the past architecture more precisely and evaluating its significance. Thus, this research contributes to define a pattern by learning from the past in order to solve the current problems.

Keywords: residential dwelling, house, daylight, natural light, Iranian traditional courtyards, Iranian contemporary house, computer daylight simulation

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To my parents and my lovely sister
for all their encouragement
throughout my career

To my uncle Faramarz,
for his sound advice and
inspirational ideas

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CHAPTER 1

1. Introduction

Man has always attempted to protect himself against natural disasters through finding a place that brings him security and peace. Initially, mankind settled in natural shelters such as caves and gradually man began to build his primary residence with similar features. Thereafter, he started developing his dwelling according to his basic needs and then, since his dwelling had a direct bearing, he endeavoured to enhance his well-being. Indeed, the concept of dwelling is more complicated than a shelter which responds to the physical needs and hence, well-being should be considered as well. Over time, well-being in a dwelling was achieved through using some specific elements such as daylight. A dwelling finds its true meaning when these elements are applied appropriately in a design process.

Daylight was used as a principal source of lighting in dwellings until the advent of electricity and artificial lighting. Daylight is more than a physical requirement and it is the key element with a significant impact on human's well-being. Studies have shown that a place well lit by daylight results in a happy, motivated and productive environment. However the impacts of daylight on human's well-being are still an evolving topic, many references suggest a strong correlation between human well-being and daylight. Therefore, it is essential to consider the important influence of daylight on human's well-being in dwellings' design process.

Through this research, daylight in Iranian residential dwellings was studied due to the importance of daylight as this was integrated into the design of traditional Iranian dwellings. The significance of daylight in Iranian dwellings has had two reasons. Firstly, daylight has had a remarkable position in Iranian's beliefs before and after Islam. Moreover, Iran's climate is mostly hot-arid and the extreme radiation of sunlight is the climatic specification of this region; as a consequence, dealing with sunlight was challenging and careful consideration has to be taken about how to illuminate a dwelling by daylight.

Daylight was the principal source of lighting in Iranian traditional dwellings (Arjmandi, Tahir, Shabankareh, Shabani, & Mazaheri, 2011; Javani, Javani, & Moshkforoush, 2010). The techniques of using daylight in Iranian historical dwellings have existed for over 10000 years, and these techniques have presented a series of logical approaches that have evolved over centuries (Babaei, Soltanzadeh, & Islami, 2012; H. Arjmandi, 2010), relying on traditional forms of Iranian architecture.

In the past several decades, the way of using daylight and the priority of daylight in traditional dwellings has fundamentally changed. Firstly, social changes have led to immigration of people from small towns or rural areas to larger metropolitan areas. The increase of population in metropolitan areas and the lack of enough urban lands to build required residences to settle the newcomers have caused morphological changes in houses and their design. The morphological changes in Iranian houses have changed the way of using daylight (Diba & Dehbashi, 2004; Faizi, Noorani, Ghaedi, & Mahdavinejad, 2011; Micara, 1999; Mirmoghtadaee, 2009; Utaberta, Sharifi, Surat, Che-Ani, & Tawil, 2012). Secondly, with the introduction of electricity and artificial lighting in Iran, and since artificial lighting has provided sufficient illumination in most contemporary uses, daylight as the principal source of lighting in Iranian houses were greatly reduced (Bahrami, 2008; Baweja, 2008; Faizi et al., 2011). Furthermore, there is also a lack of knowledge about the value of daylight on well-being and how, by reducing the use of daylight, occupants' well-being may be reduced significantly (Baweja, 2008; Heschong, 2002; Phillips, 2004).

Hence, comprehending the capacity of daylight in enhancing well-being has motivated the researcher to think seriously about how daylight might be better used in Iranian dwellings and optimizing the use of daylight in dwellings as a way to improve occupants’ well-being.

1.1. The Research Questions and Overview of the Study

Considering the wisdom of Iranian traditional architecture and the great significance of daylight in traditional dwellings when it was used as the principal source of lighting, the researcher has studied the techniques of using daylight in traditional dwellings as a model to extrapolate its positive aspects to modern dwellings. The main questions of this research that was raised from the researchers’ perspective include:

How to enhance well-being in Iranian modern dwellings through studying the techniques of using daylight in traditional houses?

Sub-questions include: Is it possible to optimize the use of daylight in modern dwellings through extrapolating the effective techniques of using daylight in traditional houses? And what are the effective techniques of using daylight in vernacular dwellings? Moreover, to what extent traditional daylight techniques were succeeded in bringing required illumination into traditional houses?

This research is aimed at understanding how daylight is used in Iranian vernacular dwellings and explores how to enhance occupants’ well-being through optimizing the use of daylight in contemporary dwellings. Therefore, through this research the techniques of using daylight in Iranian traditional houses were studied with an eye to enhancing the use of daylight and as a consequence human's well-being in contemporary residences.

First, a literature review/study of Iranian traditional houses was conducted to find out how daylight was provided in traditional dwellings and to what extent the techniques of using daylight in traditional houses were successful in bringing the required illumination into houses. Second, the research has tried to identify and study the effective techniques of using daylight in Iranian vernacular dwellings. Finally, the research has discussed the possibility of enhancing the well-being of occupants by extrapolating the effective traditional daylight techniques into contemporary dwellings. Generally, the goal of this research is to address how the use of daylight was optimized through techniques for using daylight in traditional houses, and relate this to contemporary dwellings in order to improve occupants' well-being.

In terms of methodology, first, and to establish, confirm, support and detail the research questions, the research study proceeds with two major steps: 1.the literature review, and 2. the data collection, including the survey questionnaire and the study of 3 case study traditional Iranian houses. First, through the literature review, recognized characteristics of daylight in Iranian traditional houses was examined, with a view to extrapolating the traditional techniques for using daylight and understanding how these might be applied into modern dwellings in order to optimize the use of daylight and increase occupants' well-being. In the second step of data collection, three case study houses are examined specifically and a survey questionnaire was conducted, where the opinions of Iranian experts on the main subject were collected.

The three case studies of traditional houses in Iran were examined. The research has aimed to elicit and comprehend separate meanings to construct shared meanings around the phenomenon of interest based on the researcher's interpretation. From this stance, for apprehending the shared techniques of using daylight in traditional dwellings, in three separate traditional houses, the techniques of using daylight was studied and finally shared techniques for benefiting from daylight were extracted.

The case studies were focused only on Iranian traditional courtyards, since the climate of Iran is mostly arid or semi-arid and courtyard houses are the prevalent housing-type of this region. The selection procedure of the traditional courtyard houses will be explained step by step in the next chapters. The cases (selected courtyard houses) were chosen based upon certain criteria such as a location where they were located in, an era when they were built and how they have used daylight generally. Moreover, the accessibility of photographs and architectural drawings was another criterion. The selected houses are the houses of families in the upper echelons of the social scale.

Finally, during the analysis phase of the study, the method for the analysis and evaluation of cases was done using computer daylight simulation software. Architectural drawings required for modeling the case were gathered from the photo courtesy of Iranian cultural heritage organization. The selected cases were modeled within computer modeling software (Autodesk® AutoCAD®) and redirected to the simulation software (Autodesk® Ecotect®) for the detailed analysis of daylight. Finally, after importing the cases and the attribution of materials to the cases' components, the analysis of daylight vertically and horizontally was done in the three cases.

Through the daylight analysis, the techniques of using daylight in each case were analysed, and then compared with other cases and at the end, the similarities and differences of used techniques were demonstrated. In addition, the strengths and weaknesses of each technique in benefiting from daylight were discussed. Therefore, this research not only has established a frame for presenting traditional techniques for using daylight in dwellings but also has provided a series of practical techniques for optimizing the use of daylight in contemporary Iranian dwellings and as a result enhancing occupants' well-being.

The emergent themes of the case study were compared to the extracted data from the literature review and the questionnaire to find out which one was very or less important. With the use of these three documented aspects in this study, the salient issues, themes or ideas concerning using daylight in traditional houses were extracted to extrapolate to the modern dwellings.

According to the results that were extracted from this research through the literature review, the questionnaire and daylight simulation, it was clarified that extrapolating the techniques of using daylight in traditional courtyards houses into modern dwellings can be considered as a design option to optimize the use of daylight and as a result to enhance occupants' well-being.

The analyses have revealed that the level and distribution of daylight in traditional dwellings have depended on various factors such as the layout, the orientation and proportions of each case in addition to the location, layout and size of openings. These factors were orientated to optimize the use of daylight by the position and movement of the sun. The layout, orientation and the proportions of each case besides the location, the layout and the size of windows, in addition to the glazing's' features, including the nature of the glass, the transmission value and etc., have made a huge difference in the level and distribution of daylight which were received.

According to the findings of this study apparent aspects were discussed; however, there are still some additional clues required to be considered. While dealing with daylight simulation, there are numerous computer programs to analyze daylight and all needs accurate building models, material representation, and weather data. For producing an exact daylight analysis, accurate data are required to calculate daylight. In this research, a variety of daylight simulation programs were evaluated and finally Autodesk® Ecotect® was selected for conducting daylight simulation through the cases. The Autodesk Ecotect was selected mainly because of the software's user-friendly interface, its compatibility with modeling software (Autodesk® AutoCAD®) which was used in this research and furthermore the software's capacity to present accurate analysis in a relatively short time.

There are also various units to measure the daylight. Deciding about the appropriate measuring unit was a considerable section of this research. Finally, for measuring the interior illumination, lux was chosen. Lux is the unit of illuminance in the International System of Units (SI) that refers to the intensity of light.

The findings of this research can be applied in modern and future dwellings to maximize the use of daylight and consequently to enhance occupants' well-being. This research contributes to authorities or decision makers who are enthusiastic to improve well-being through using daylight in design. This study will impact on residential design through presenting an approach for improving occupants' well-being by increasing the use of daylight in dwellings. This approach provides an opportunity for studying traditional residential architecture more precisely and evaluating its significance in term of using daylight and extrapolating its positive aspects into modern dwellings. This research study has established a pattern to solve the contemporary daylight problems through learning form the past.

1.2. The Context

In the course of the contemporary period (from the first of the 20th century until today), the intensification of Iran's contact with the Western nations and the acquaintance with the industrial and economic development of these countries which had led to growth in all aspects and fields in the West encouraged Iranian governors and authorities to follow a series of wide spread social and cultural changes in Iran with following what existed in the West. The social and cultural reforms have caused principal structural changes in the big Iranian cities and the fast development in their context (Diba & Dehbashi, 2004; Micara, 1999).

The charisma of the development in the Iranian metropolises raised a very strong motivation and enthusiasm in the residence of villages and remote towns to immigrate to these big cities (Faizi et al., 2011; Utaberta et al., 2012). For instance, according to censuses and surveys which were conducted by the Statistical Centre of Iran (SCI), the population of Tehran (the capital of Iran) began to increase about 1921 within 40 years became ten times as much, reaching 2 million in 1961 and in the next forty years, from 1961 to 2001, the population reached 7 million. Now, Tehran's population is 7.7 million.

The result was a high rate of immigration and consequent population increase which has necessitated providing the sufficient residential buildings to settle the newcomers. The lack of enough urban lands to build sufficient dwellings has led to morphological changes in Iranian traditional houses. The morphological changes of Iranian houses have caused principal changes in the way of using daylight in modern dwellings. (Faizi et al., 2011; Mirmoghtadaee, 2009; Utaberta et al., 2012).

In the contemporary era and with the advent of electricity, a new source of lighting was introduced. Soon, the artificial lighting has become so popular because it has offered many advantages. First of all, artificial lighting has provided enough illumination in most modern circumstances. Next, it has had a capacity to reply to all lighting needs. Finally, it was easily accessible. All these benefits, in addition, the lack of sufficient knowledge about the significant impacts of daylight on well-being have led to the reduction of using daylight. Accordingly, artificial lighting has replaced daylight as the main source of lighting in Iranian dwellings leading to a marked reduction in the use of natural daylight as an architectural feature. Hence, by decreasing the use of daylight, users' well-being which is correlated with daylight decreased as well (Baweja, 2008; Heschong, 2002; Phillips, 2004).

Therefore, understanding the ability of daylight in enhancing well-being has motivated the researcher to reflect seriously on increasing the use of daylight in Iranian dwellings to improve the occupants' well-being. In other words, since occupants' well-being is enhanced through optimizing the use of daylight in dwellings; this research has intended to enhance occupants' well-being through increasing the use of daylight in dwellings.

1.2.1. The Role of Daylight in Traditional Iranian Dwellings

Meanwhile, daylight has been held in high esteem as a feature in Iranian traditional dwellings because of two principal reasons. Firstly, daylight has been respected as a sacred element in Iranian beliefs (Arjmandi et al., 2011; Javani et al., 2010). Secondly, Iran's climate is mostly hot-arid and the extreme radiation of sunlight in this region necessitates taking careful consideration about dealing with natural light (Maleki, 2011; Zaimi, 2010). Furthermore, daylight was used as the principal source of lighting until the advent of artificial lighting (Babaei et al., 2012; H. Arjmandi, 2010). The traditional techniques of using daylight in Iranian dwellings have been in existence for over 10000 years and with applications to houses having been evolved over centuries.

The researcher has studied the techniques of using daylight in traditional dwellings as a model to extrapolate its positive aspects to modern dwellings by considering the wisdom of traditional architecture and the significance of daylight in traditional dwellings when it was used as the principal source of lighting,. In other word, since enhancing the use of daylight in dwellings improve occupants' well-being, The researcher through this master project has studied and analyzed the daylight techniques in Iranian traditional dwellings to be used as a pattern to optimize the use of daylight in modern dwellings and consequently enhance their occupants' well-being.

Thus, the principal question of this research is: How to enhance well-being in Iranian modern dwellings through studying the techniques of using daylight in traditional houses?

Sub-questions include: Is it possible to optimize the use of daylight in modern dwellings through extrapolating the effective techniques of using daylight in traditional houses? And what are the effective techniques of using daylight in vernacular dwellings? Moreover, to what extent traditional daylight techniques were succeeded in bringing required illumination?

The process of responding to these questions highlights strengths and weaknesses of the techniques of using daylight in traditional dwellings in Iran and also indicates the efficiency of these techniques in benefiting from daylight. Analyzing and evaluating daylight in traditional houses have brought up findings about the techniques of using daylight in traditional residences which can act as guidelines for modern residential design. Since, the findings of this study was extracted from a model (the traditional courtyard houses) in which daylight was utilized as the primary source of lighting, these findings have the capacity to choose as an applied option for contemporary dwellings to optimize the use of daylight and enhance occupants' well-being.

This research has proposed strategies for optimizing the use of daylight in modern dwellings with regard to the techniques of using daylight in traditional courtyards houses. Thus, traditional courtyards were studied and evaluated in term of benefiting from daylight and techniques by which daylight were utilized. Hence, by considering the weaknesses and strengths of these techniques for using daylight, strategies for increasing the use of daylight in contemporary dwellings were proposed in order to enhance well-being. In other words, the goal of this research is to address how the past dwellings utilized the daylight as an effective lighting solution, and relate this to future dwellings to improve well-being.

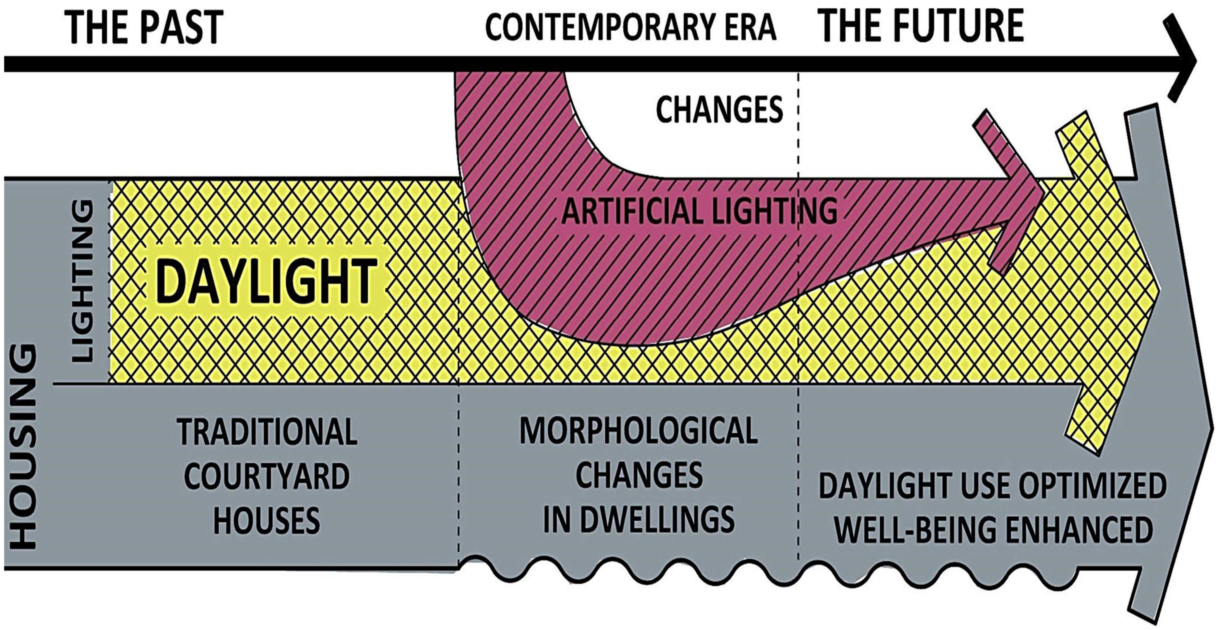

Figure 1-1: Conceptual drawing, enhancing well-being though increasing the use of daylight in modern houses. Created by author

1.3. Iran and Historic Contexts

Iran, formerly known as Persia, a Middle Eastern country lies in western Asia. Iran is located between the Caspian Sea on the north and the Persian Gulf on the south (see Figure 1-2). It encompasses around 1,648,000 square kilometres (636,000 sq. mi) and has a population of around 75.15 million; the large majority of whom (89%) are adherents of the Shi'a branch of Islam, around 9% are Sunni Muslim, with Zoroastrian, Jewish and Christian forming around 2% (Bahrami, 2008; Jones, 2009; Zarkesh, Moradchelleh, & khanlari, 2012).

Figure 1-2: Iran location on the globe. Retrieved from www.maphill.com

Figure 1-3: Iran boundaries 2012. Retrieved from www.cia.gov

The country has very rugged mountainous areas as well as a high central basin with deserts. Along its coasts, there are small patches of plain. Iran's climate is divided in at least four different zones (A'zami, Yasrebi, & Salehipoor, 2005; Bahrami, 2008; Zaimi, 2010; Zarkesh et al., 2012): 1. Cold climate in mountain and high plateau region. 2. Temperate and humid climate along the Caspian Sea coast. 3. Hot and dry climate in central plateau. 4. Hot and humid climate with high humidity along the Persian Gulf and Oman Sea.

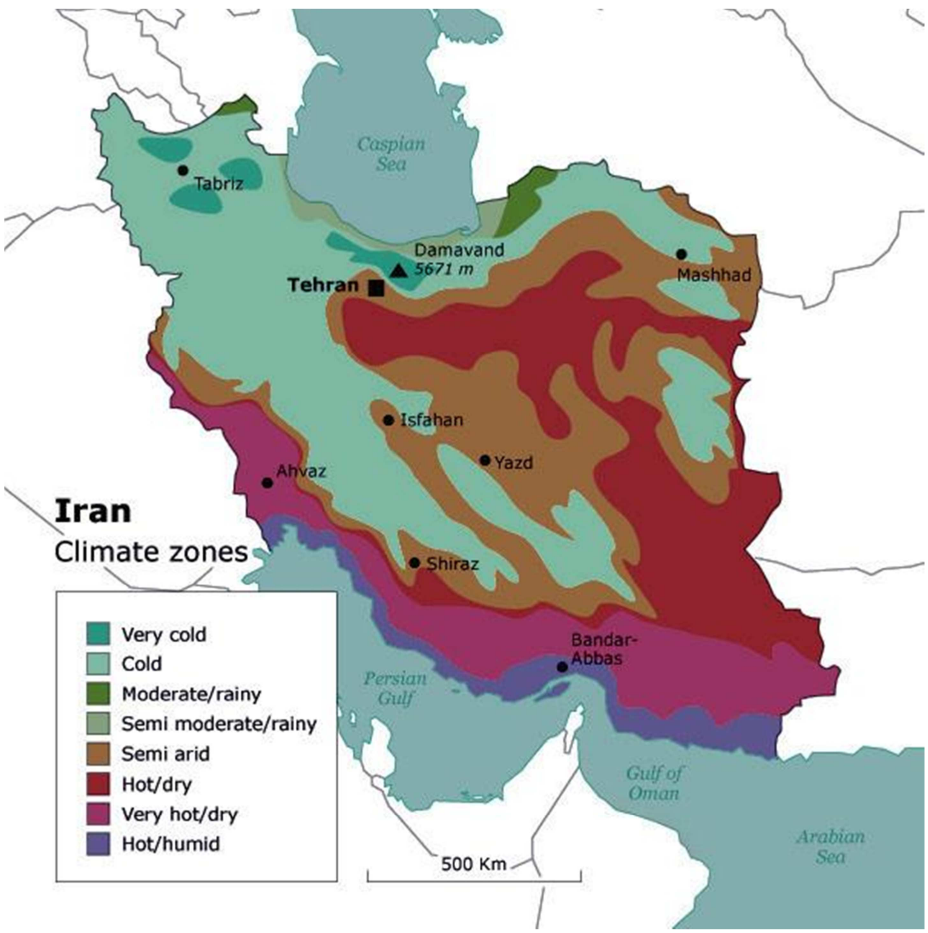

Figure 1-4: Iran's climatic classification. Retrieved from www.fanack.com

Iran’s climate is mostly arid or semi-arid (A'zami et al., 2005; Bahrami, 2008; Zaimi, 2010). This area is characterized by long, hot, dry summers and short and cold winters. It is totally barren with a very low rainfall. Low moisture and lack of clouds in sky in the most months causes great ranges of temperature changes in this area. Temperature fluctuations sometimes reach 20 centigrade degrees in a day. Furthermore, the extreme radiation of sunlight, high temperature in hot seasons, and relative dryness of atmosphere are considered as climatic specifications of arid or semi-arid region of Iran (Maleki, 2011; Zaimi, 2010).

1.3.1. Iran’s History

Iran is one of the oldest civilisations of the world. The history of this country is traced back to the union of the local tribes by Cyrus of Persia and the foundation of the Achaemenids Empire in the 6th century BC; however earlier states such as Elam (4^{th}-3^{rd} millennia BC) or Media (9^{th}-6^{th} century BC) was existed. History of Iran is traditionally divided into two principal periods: pre-Islam (before 7^{th} century AD) and post-Islam (Hajjar, Naghizadeh, & Aminzadehgoharrizi, 2011; Pirnia, 2004; Pope, 1965).

1.3.1.1 Pre-Islamic Period

The Achaemenid Empire which was stretched from the banks of Nile to Indus was overthrown by Alexander of Macedonia in 4^{th} century BC. In the middle of the 3^{rd} century BC, the new state of Parthians emerged and defeated

Alexander's descendants (Seleucids). After the Parthians, Sassanids came to power and was the last empire ruled over Iran before the advent of Islam.

1.3.1.2 Islamic Period

The Sassanids were overdrawn by Muslim Arabs in 7th century AD. Iran was governed by Islamic Caliphates during 11th-14th century AD. Then, Iran was invaded and controlled by Turks and Mongols. But in 15th century AD, a new renaissance took place by rising of Safavids dynasty (15th-18th century AD). After Safavids, (17th-18th), Zands (18th), Qajars (18th-20th), Pahlavi (20th-1979) and current Islamic republic state, each respectively governed Iran until now.

1.4. Iranian Architectural History

Iran is a country with ten thousand-year architectural history. Cultural values, religious beliefs and climatic factors influenced on Iranian traditional architecture. Therefore, Iranian architecture was constructed in accordance with their environment where they were located in (Pirnia, 2004; Pope, 1965). From the late of the Safavid dynasty (18th AD), the commencement of frequent contacts with developed Western countries led to significant changes in Iran and its architecture (Diba & Dehbashi, 2004; Micara, 1999). Thus, the architectural history of Iran can be divided in two principal periods: the traditional period which points out to the vernacular architecture of Iran before being impacted by the changes and contemporary period which contains afterwards.

1.4.1. Traditional Architecture

The history of architecture in Iran dates back to the early settlements in 10,000 years ago (Pope, 1965). Iranian traditional architecture since the preliminary phases of building by the unknown tribes was a stage of a continuous interaction between users and their surroundings. Thus, it was a demonstration of practical responses to the users' requirements. This process progressively was continued and developed by the end of glorious architecture in Safavid era (1720 AD) (Micara, 1999; Pirnia, 2004).

1.4.2. Contemporary Architecture

The contemporary era refers to a period from the end of Safavid dynasty until today which contains the dynasties of Safavid, Qajar and Pahlavi and Islamic Republic era.

Safavid Era

In the late of the Safavids period (1720 AD) confrontation with West began, led to dawning of a new era in Iranian architecture. At this time Isfahan, the capital of Iran, was the destination of many Western visitors and ambassadors. These Westerners, by providing an account of what happened in The West, generated curiosity and shared knowledge in Iranians that can be seen in some architectural works of that time. The great plan of Safavids for Isfahan looks Oriental and definitely Persian but its features are near the projects of the late Renaissance and Baroque(Micara, 1999).

Qajar Era

Contacts with the West were intensified under Qajar dynasty (1794-1925 AD). The more communications between Iran and West allowed increasing acquaintance with the Western civilisation. Qajar princesses and authorities inspired by the West enacted reforms which led to the groundwork for the appearance of a developed country. The preliminary stage of Iran's modern architecture took place during this time and influenced by Western modern architecture (Diba & Dehbashi, 2004; Ghobadian, 2010).

The city most affected in its form and image in this period was Tehran, capital only since 1798. In Qajar era, the image of Tehran was changed by increasing Western influence. Lord George Curzon wrote in 1892 about Tehran, "In a word, we are in a city which was born and nurtured in the East, but is beginning to clothe itself at a West End tailor's". It is a unique picture of an architecture which was gradually missing its Oriental character (Micara, 1999).

The First Pahlavi Era

After falling of the Qajar dynasty, Pahlavi rose to power in 1925. This shift in power occurred while the Iranian society was experiencing an important confusion between its traditions and a series of reforms based on western civilization. The inconsistency of the late Qajar rulers was replaced by a rapid acceleration towards modernization and industrialisation and led to transformation of Iranian metropolises such as Tehran into new and modern cities (Micara, 1999).

In this period, Iranian architecture was carried out by either a group of architects who were trained in the West or Western architects who were invited to Iran for designing new buildings. Their works to a large extent was under impact of the Western architecture. In this era buildings not only in terms of architectural styles but also in terms of constructional technology inspired by the West (Diba & Dehbashi, 2004).

The Second Pahlavi Era

This approach was continued by second Pahlavi who rose to power in 1941. From 1969 to 1978 with the aid of oil income, important developments were made in different fields especially in architecture. In this period, the dramatic population increase in metropolises led to a profit-making attitude aimed at faster, cheaper construction. What appeared at the end of the Pahlavi era in cities was an inharmonious combination of build-and-sell architecture (Diba & Dehbashi, 2004; Ghobadian, 2010; Micara, 1999).

Figure 1-5: Housing construction, the Pahlavi era

Figure 1-6: Housing construction, the Pahlavi era

Islamic Republic State

The Islamic Revolution in 1978 and the eight-year imposed war with Iraq created many social and economic disturbances which influenced on the Iranian architecture. During imposed war, the Iranian architecture only focused on the primary essential needs and ignored other aspects (Diba & Dehbashi, 2004; Micara, 1999). The political and economic matters after the war led to the same architecture which has been continued until now.

Figure 1-7: Housing construction, the Islamic republic era

Figure 1-8: Housing construction, the Islamic republic era

1.5. Summary of the Research Objectives

1.5.1. Major Objective

The major objective of this master's project is to study and understand daylight in the traditional courtyard houses, to evaluate the techniques of using daylight in these houses and to extrapolate the effective techniques of using daylight in courtyards into modern contemporary dwellings in order to optimize the use of daylight and as a result to enhance occupants' well-being. As mentioned the principal research question which was asked is: How to enhance well-being in Iranian modern dwellings through studying the techniques of using daylight in traditional houses? Secondary questions include: Is it possible to optimize the use of daylight in modern dwellings through extrapolating the effective techniques of using daylight in traditional houses? And what are the effective techniques of using daylight in vernacular dwellings? Moreover, to what extent traditional daylight techniques were succeeded in bringing required illumination?

In essence, it is of interest to uncover the potential of sunlight and daylight (specifically through study the past residential architecture when daylight was used as the primary source of lighting), to offer a way to optimize the use of daylight in modern Iranian dwellings in order to enhance occupants' well-being.

1.5.2. Stages of Research

- Studying about daylight in Iranian houses through reviewing literatures. This review has focused firstly on daylight and its positive impacts on occupants' well-being in dwellings. In the second step, the position and significance of daylight in Iranian dwellings was studied. Then, the research has reviewed the contemporary morphological changes in Iranian houses which have changed the way of using daylight in dwellings. Finally, the techniques of using daylight in traditional courtyard houses were studied and the effective techniques were highlighted.

- Conducting interviews with 8 Iranian experts, well-known architects who are currently involved in academia and in designing residential buildings in Iran; according to the basic knowledge which was obtained through the literature review. This stage has included collecting the opinions and viewpoints of Iranian experts about the importance of daylight in dwellings, the contemporary changes in the way of using daylight in Iranian houses, how daylight was used in the traditional courtyard houses and on the possibility of extrapolating the traditional techniques of using daylight into Iranian modern dwellings to optimize the use of daylight.
- Creating a daylight simulation exercise consisting of three steps: firstly, selecting 3 cases with the same features amongst Iranian traditional courtyard houses in a historic study site. Secondly, computer modeling of the 3 cases. Finally, the analysis of daylight and the techniques of using daylight in the 3 cases through daylight simulation software. This includes simulating and analyzing daylight in traditional houses and comparing achieved results with the daylight standards of Iran for residential buildings to understand how much the traditional techniques of using daylight were succeeded in providing required illumination. Moreover, the research has studied the impacts of highlighted traditional daylight techniques, extracted from the literature reviews and Iranian experts' interviews, on daylight which was provided.

CHAPTER 2

2. Literature Review

The literature review of this research focuses on three principal parts. The first section presents basic definitions for the structural components of this question such as daylight and the notion of using daylight, its historical background and a brief introduction to Iranian traditional houses and to the transition period in Iranian dwellings. In the second part, previous studies and literatures on daylight characteristic and features in traditional houses of Iran is collected and reviewed. This part lets to obtain an overall understanding about the techniques of using daylight in courtyards houses. Finally in the last part, the literature review is conducted on the existing technological tools for analyzing and evaluating daylight.

First, daylight as the central elements of this research will be defined. The nature of daylight will be discussed and the brief history of using daylight will be reviewed. Then, the significant effects of daylight on occupants' well-being will be reviewed. In the following, the studies will be specified on Iran by reviewing the Iranian philosophy of the light. Certainly, for understanding the features of using daylight in the Iranian traditional houses, understanding of their basic structure will be essential, thus these houses and their principal components will be studied before reviewing the daylight features in theses dwellings.

In the second part, the important characteristics of using daylight in Iranian traditional courtyards will be collected and reviewed. This part lets to find a general understanding about the daylight features used in the traditional courtyards which were already studied by other researchers.

Finally, in the last part, since for analyzing and assessing every issue, an appropriate criterion is required, certain criteria for analyzing and evaluating daylight in traditional houses will be reviewed. Among them the best one which covers this research's requirements will be selected and will be precisely reviewed. Hence, in the last section, daylight software simulation as the selected criterion will be defined.

2.1. Daylight

"Architecture comes from the making of a room. A room is not a room without natural light." Louis Kahn (Hawkes, 2011)

The sun is the greatest source of energy on the earth and with no doubt the existence of all creatures is reliant on the energy produced by the sun. The solar energy radiated by the sun is an infinite and nonpolluting source of energy, in contrast to the limited fossil fuels coal, petroleum and natural gas. Thus, through history, the sun was always used as a principal source of lighting and heating in buildings. The sun, as the source of light, was represented as a symbol of activity, strength, health, hope and worship; also valued as a sacred and divine element in many cultures (Almaiyah, Elkadi, & Cook, 2011; Gholam Hossein Naseri, 2011; Sabzipour, Mirhadi, & Asgharzadeh, 2013).

Since nothing is seen in darkness, the natural light is an element with a magical power. The natural light arouses wonderful feelings and creates positive impressions instantly or permanently. The importance of natural light was stated by many well-known architects including Louis Kahn who in his lecture in 1961, "Law and Rule in Architecture", explained: "Every space must have natural light, because it is impossible to read the configurations of a space or shape by having only one or two ways of lighting it. Natural light enters the space released by the choice of construction.” (Kahn, 2003).

2.1.1. What Is Daylight?

The solar energy radiated by the sun passes through the space and reaches to the external layers of the atmosphere. (Britannica, 2013; Heier & Österbring, 2012). Then, the light is divided in three ways: A part of the light passes through the surface; some light is reflected and scattered by the atmosphere and the last part is absorbed and turned into heat. The ratio of the light passes the atmosphere and arrives to the earth's surface is called sunlight.

However, the sunlight is only a part of the solar radiation but constitutes about 50 percent of the solar energy. It consists of nearly 50 percent visible light, 45 percent infrared radiation and smaller amounts of ultraviolet (Britannica, 2013; Heier & Österbring, 2012). Since infrared radiation has its chief merit in its heat-producing quality, the sunlight brings both the daylight and the thermal load to the building.

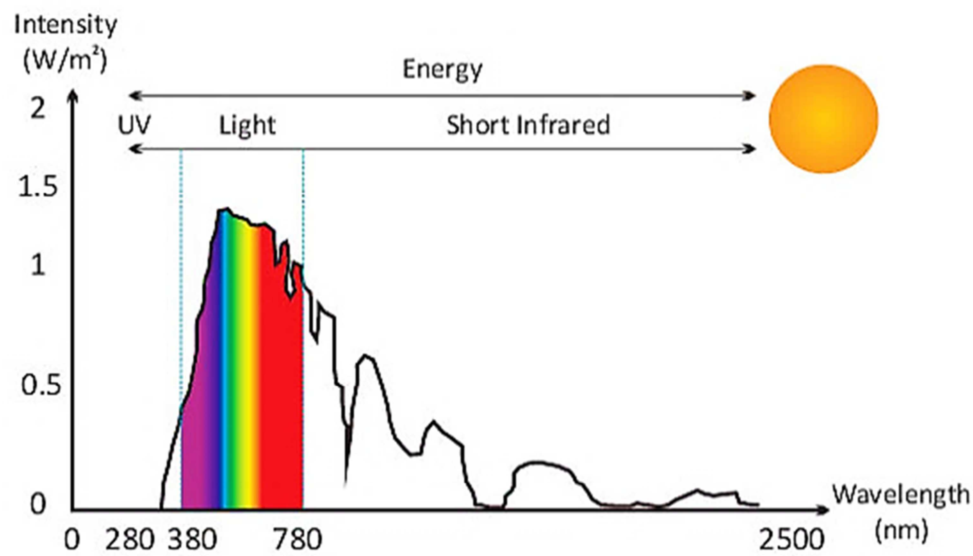

Figure 2-1: The solar spectrum, sunlight is broken into three major components: 1. visible light, with wavelengths between 0.4 and 0.8 micrometre, 2. ultraviolet light, with wavelengths shorter than 0.4 micrometre, and 3. infrared radiation, with wavelengths longer than 0.8 micrometre. Retrieved from www.fgglass.com

The daylight, as a noun, describes all direct, diffuse[1] and reflected sunlight during the daytime. As a verb, daylight is the art, science and practice of using daylight as the main daytime source of light in built environments (Ternoey & Principal, 1999). Hence, daylight affects various aspects of a built environment such as occupant's well-being (physiological and psychological) (Çakir, 2009; Edwards & Torcellini, 2002). Using daylight can improve occupant satisfaction, as it increases productivity and health. (Phillips, 2004).

[1] Diffuse daylight is light that was scattered in the atmosphere before reaching the Earth's surface

2.1.2. The History of Using Daylight

In the earliest caves, the daylight let the man know the change of night and day; thereafter, as dwellings became gradually more sophisticated, the daylight brought the required illumination into spaces through openings. However, by mastering fire a new era began and the man's control to light his built environment was improved, but daylight remained as the principal means of lighting until the early twentieth century (Phillips, 2004).

The man's attempt to becoming more and more independent of the nature led to his reliance on invented technologies for controlling the built environment. Hence, this process led human to become completely dependent on artificial self-made enclosures. Then, as a consequence, for various reasons, even the primary role of daylight was questioned.

From the 1900s by the invention of electricity, the advent of artificial lighting and the abundant inexpensive energy a new era began. In particular, by the 1960s and 70s, electric lighting supplanted the daylight as the principal source of lighting (Baweja, 2008; Phillips, 2004). The artificial lighting sources were able to create any atmospheres no matter what the conditions were outside. Hence, little by little the requirements for minimum daylight in building codes began to be abandoned (Baweja, 2008; Phillips, 2004).

By the OPEC oil crisis in 1973, the energy conservation emerged as a common environmental concern. By understanding that our dependence on fossil fuels has its limitations, people started to question this high consuming energy approach, and began to search ways to reduce the energy consumption. Therefore, reducing electricity load in buildings by means of daylight came into focus. It was obviously a source with minimal impact on the environment, it was completely free and had maximum positive impact on building occupants if it was effectively controlled (Baweja, 2008; Heschong, 2002; Phillips, 2004).

At this time, the notions such as sustainable architecture, climate-responsive design or energy-conservative design began to take on greater importance (Baweja, 2008). Indeed, these approaches in design use methods, systems and materials that do not deplete resources or harm natural cycles (VanZee, 2011). Daylight as the heart of these new philosophies emerged at the centre of the architectural strategies (Phillips, 2004). By using appropriate daylight techniques, human, environmental and economic performance increased significantly compared to electric lighting.

2.2. Daylight and Well-Being

Daylight-based design has always focused on the environmental and economic benefits of reducing energy consumption. By the late 70s and early 80s, new issues including human's health and performance in day-lit buildings began to be discussed as well, due to poor artificial light source issues. However the impacts of daylight on occupants' well-being are still an evolving topic, many references suggest a strong correlation between occupants' well-being and daylight in buildings (Ternoey & Principal, 1999).

As social patterns increasingly move us indoors during daytime hours, we find ourselves relying on artificial lighting now more than ever before. For instance, Americans and Canadians spend as much as 90 percent of their time indoors (EPG, 2009), it would be a mistake to accept the energy efficiency as the principal measure to assess good daylight in buildings. Our intuitive and deeply spiritual relationship with daylight also has to be considered as well as his physical and psychological effects on our well-being (Baweja, 2008; Robertson, 2003).

Factors like climate, tradition and sometimes prejudice determine the degree to which the daylight is liked. But generally all people physically and psychologically desire to be connected to what is happening outside (Ne'Eman, 1974). In this case, windows and openings bring people into contact with the outdoor world and let them have a relationship to the sun, the sky and to experience changes of the sunlight, the weather, time of day and the seasons. People are inside while still feeling connected to their outdoor environment.

Lighting conditions can influence the performance of individuals by the visual, perceptual and the circadian system. Physiologically, daylight is an effective stimulant to our visual system. But human perception of light does not only rely on physiological lighting requirements. The visual and psychological aspects of light are equally important. Studies made on dwellings have shown a strong connection between daylight levels and window location to their impact on visual comfort of occupants (Almaiyah et al., 2011; Çakir, 2009; Gholam Hossein Naseri, 2011; Heier & Österbring, 2012).

The lack of daylight causes health issues like circadian malfunctioning. Indeed, the human circadian system, a physiological system that helps people judge night from day, uses daylight to stay in synchrony with its environment as the diurnal or seasonal change. Light falling on eyes controls the body's circadian rhythm. If circadian rhythm does not match the day rhythms causes feeling of drowsy, tired, and distracted. For instance, fatigue, the most common symptom among sick building syndrome, is a subsequent of circadian malfunctioning. Furthermore, the inappropriate use of daylight and the lack of sunlight are responsible for Seasonal Affected Disorder (SAD), which affects a large number of people at certain times of the year due to the lack of sunlight. The daylight reduces the incidence of health problems which are caused by the quick fluctuations of the electric lighting output with discharge lamps (Çakir, 2009; Joseph, 2006; Phillips, 2004).

2.3. Daylight in Iran

Light was playing important role in Iranian culture and traditional architecture. It has a respectful position in Iranian's beliefs since ancient times until today. The light is considered as a holy phenomenon in Iranian religions such as Mithraism, Manichaeism, Zoroastrian and Islam. In Mithraism, Sun was praised as god of light and faith. In Manichaeism, it would be believed that everything in this world which is beautiful has worth to be worshiped. This beauty belongs to the spirit and is related to a luminous supreme arena.

The darkness and the lightness in Iranian culture sometimes reach to the harmony and sometimes present the struggle between goodness and badness. Based on Zoroastrian thought, interaction of lightness and darkness is phenomena which created the world. In Zoroastrian, The struggle between darkness and lightness forms the basis of thought and it was believed that existence was created by the interaction of two forces or two essences of lightness and darkness. In Islam, according to Quran`s verses, God is explained by comparison with natural phenomena, such as the invisible, colorless light (Ahani, 2011; Javani et al., 2010; Makani, Khorram, & Ahmadipur, 2012). The influence of these mystic's opinions can be recognized in artistic works. As a result, the presence of light in their works is a reflection of their beliefs.

2.4. Traditional Courtyards

The traditional dwellings in hot-arid region are mostly single story built of adobe or mud brick. They have a courtyard or more that the rooms are arranged around its sides and have openings to it. The courtyard functions as an articulation to unite different spaces of the house. The courtyard house consists of a series of various spaces. Entrance leads to the courtyard with a long passageway. The concept of the passageway is to block direct sight to the courtyard and provide enough privacy for dwellers in their residences (Memarian & Brown, 2003; Moradi & Akhtarkavan, 2008).

Figure 2-2: The southern face of courtyard, Ameri house, Kashan, Iran. Photo courtesy of author

Figure 2-3: The northern face of courtyard, Ameri house, Kashan, Iran. Photo courtesy of author

A vestibule is situated right next to the entrance as a stopping point and could be used as a temporary reception space. The house is usually divided into two zones: one used as the family (interior zone) and other one allocated to the guest (exterior zone) (see Figure 2-4). The interior zone is located near the entrance but the exterior zone has spread in other sectors. Therefore, hierarchy of spaces begins with public spaces, continues with semi-public, semi-private and ends with private ones (Atefeh Zand Karimi, 2012; Nabavi & Goh, 2011).

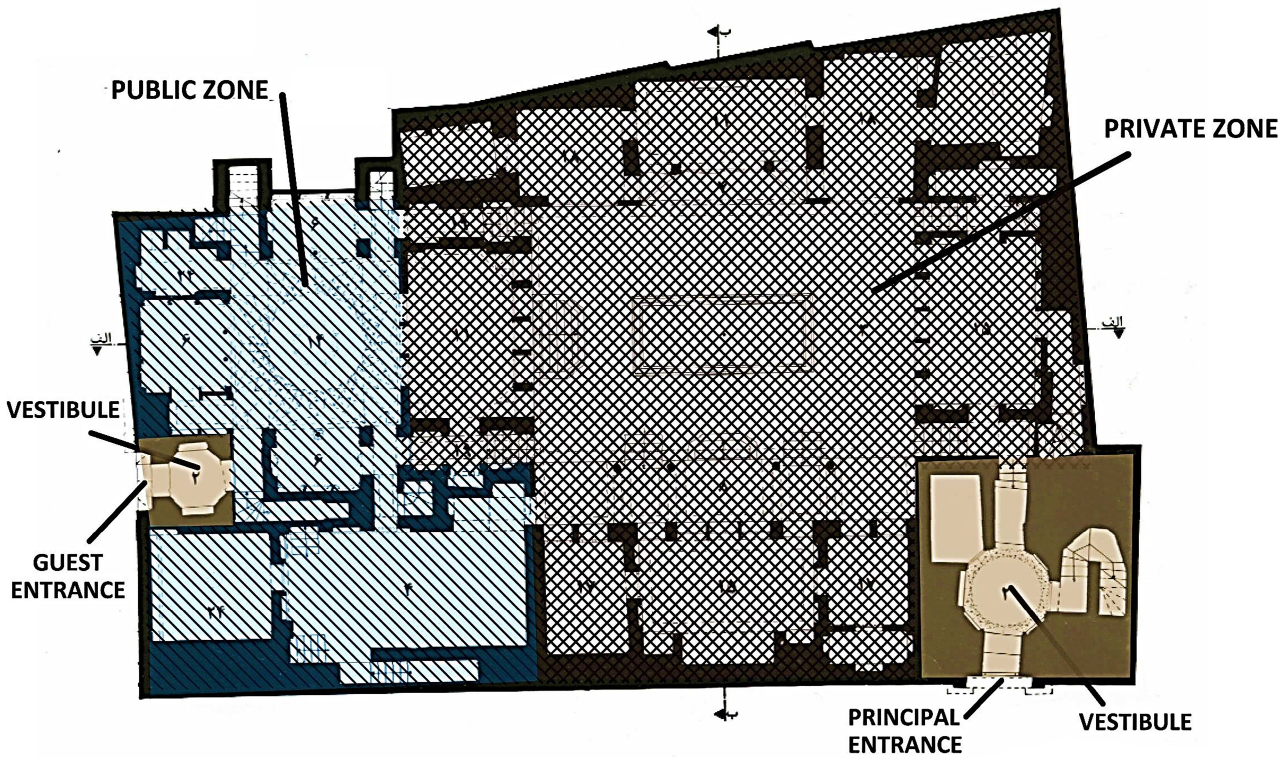

Figure 2-4: The main parts of courtyard , using two zones (private and public) was a strategy to provide Iranian courtyards with enough privacy as well as vestibules which was situated right next to the entrances. Jahan-ara'i house, Kashan, Iran. Photo courtesy of the cultural heritage organization of Iran, edited by author

In courtyard houses, there is a set of room-types which has common names and the same physical characteristics. The rooms are known by number of their doors faced to the courtyard. The three-door room and five-door room are the most typical ones. These rooms are located on each side of the courtyard with respect to the symmetry of the design. The room were normally entered by a short passageway at one or both sides. The three-door room and five-door room have multi-functional roles. The three-door room acts as a bedroom, a winter or autumn sitting room and especially in the evenings as a guest room. While, the five-door room could be a reception room, a family meeting room, or a dining room. (Memarian & Brown, 2003; Nosratpour, 2012).

Figure 2-5: The exterior view of five-door room, Yazd, Iran. Photo courtesy of author

Figure 2-6: The exterior view of three-door room, Yazd, Iran

2.5. Transition in Iranian Dwelling

The history of dwellings in Iran dates back to the early highland settlements in 10,000 years ago (Pirnia, 2004; Pope, 1965). Iranian dwellings were built through embodied experiments of users during the time. In the contemporary era which has referred to a period from late Safavid dynasty up to present including the Safavid, Qajar and Pahlavi besides Islamic Republic eras), the structure of Iranian dwellings were changed significantly (Diba & Dehbashi, 2004; Micara, 1999; Mirmoghtadaee, 2009).

Indeed, the social, industrial and technological changes have caused serious morphological changes in Iranian dwellings (Diba & Dehbashi, 2004; Micara, 1999; Soltanzadeh, 2005). This transition period of Iranian dwellings was categorized and reviewed in two phases according to a chronological order: First period has started form the middle of Qajar era and continued into the middle of Pahlavi era. Then, from the Qajar era these changes have continued until the present day.

2.5.1. The First Period

After urban developments in Qajar era which occurred under the influence of Western urbanism, residential land lots reduced in size and were shaped more geometrically (Kazemipour & Mirzaie, 2005; Sharifi & Murayama, 2013). They were mostly rectangular and they had a southern-northern orientation similar to the orientation of traditional courtyard houses. But since the new residential land lots became smaller and narrower in size, building the new dwellings by following traditional courtyards' patterns was impossible.

Hence, instead of traditional courtyard houses in which yard was located in the middle and surrounded completely with built areas, the new dwellings had only two built areas in northern and southern parts with a yard in the middle. In the northern part, where the house faced the sun, a main two-storey residential area was located. The ground floor was considered for living areas and the first floor for guests. The other built area in southern part usually was one-storey with a basement. The kitchen and service areas were situated in the basement. Later by coming electrical and mechanical systems in kitchen and service areas which were usually far from living spaces, they were located closer to the main living areas (Mirmoghtadaee, 2009; Soltanzadeh, 2005).

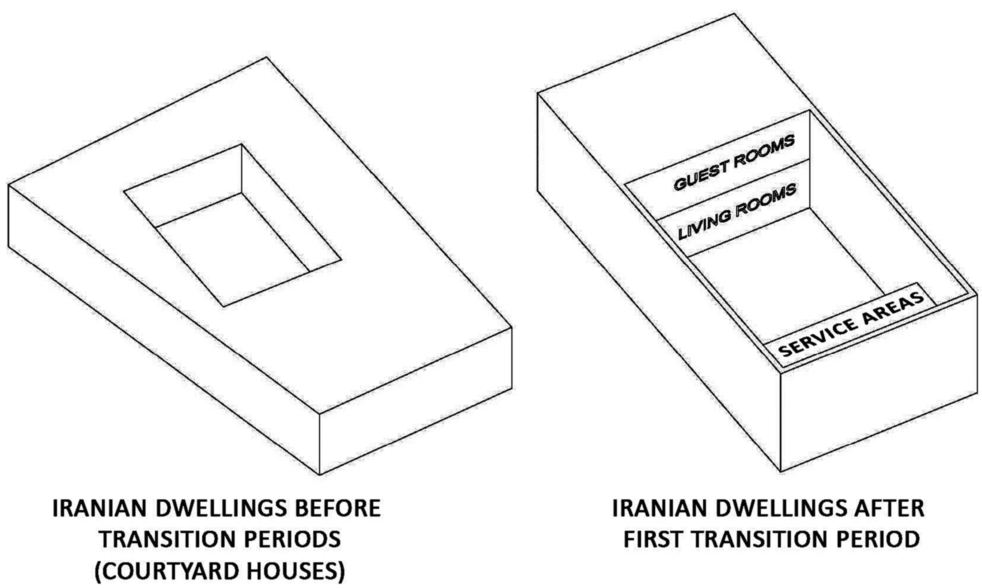

Figure 2-7: The transition of Iranian dwelling's structure during the first period. Created by author

2.5.2. The Second Period

In this period, four main reasons have influenced on Iranian households and changed the structure of Iranian dwellings. Firstly, the demographic changes have occurred during this era (Mirmoghtadaee, 2009; Soltanzadeh, 2005). For instance, a study conducted from 1936 to 1966 has shown that each Iranian woman in rural and urban area had the average of 6.5 children. Similar studies have shown that this average in 1966 was 7.7 in rural and in urban areas. But in 2000 this average has decreased to 2.17 children for each woman in rural and urban areas of Iran. Furthermore, other studies have shown that in 1986, 80.1% of total households in Iran were nuclear families, 6.3% were extended families and 13.6% consisted of single-person households. But the proportion of nuclear families increased to 83.5% of total households in 1996 and conversely the proportion of extended families decreased to 0.4% (Mirmoghtadaee, 2009; Soltanzadeh, 2005). Hence, the studies have shown that extended families have replaced nuclear families. Consequently, large traditional courtyard houses which were designed to accommodate several generations of an extended family were changed to recent small modern residential units to suit the newer family structures.

Secondly, the increase of population in large cities due to immigration from rural areas and small towns and the limitation of urban lands has prevented constructing traditional large low rise dwellings (Bani Masoud, 2009; Diba & Dehbashi, 2004; Micara, 1999; Sharifi & Murayama, 2013) changing the nature of residential dwellings. For instance, according to censuses and surveys which were conducted by the Statistical Centre of Iran (SCI), the population of Tehran (the capital of Iran) which began to increase about 1921 and within 40 years became ten times as much, reaching 2 million in 1961 and in the next forty years, from 1961 to 2001, the population reached 7 million. Now, Tehran's population is 7.7 million. Thus, high rise small residential buildings have replaced low rise large courtyard houses.

Thirdly, simultaneously, the introduction with new building technologies and materials such as steel and concrete and with the addition of elevators in buildings all have led to construction of high rise buildings in Iran and as influenced by Western architectural developments. These all reasons have contributed to the increase in new high rise small apartment units (Bani Masoud, 2009; Diba & Dehbashi, 2004; Micara, 1999; Sharifi & Murayama, 2013).

These changes have changed the use of housing with the larger, traditional houses having been largely abandoned while small apartment buildings have become more prevalent. The new dwelling has a smaller residential area for each household and a shared courtyard which belongs to all residents of an apartment building. Based on the new municipal legislations of residential buildings in Iran, the 60% of land lot is constructed while 40% is left for open spaces. This issue has had a great effect on the spatial layout of Iranian houses, not to mention the ways that families use the dwellings. Finally, now a yard is located in the front of each multi-storey building(Mirmoghtadaee, 2009; Soltanzadeh, 2005).

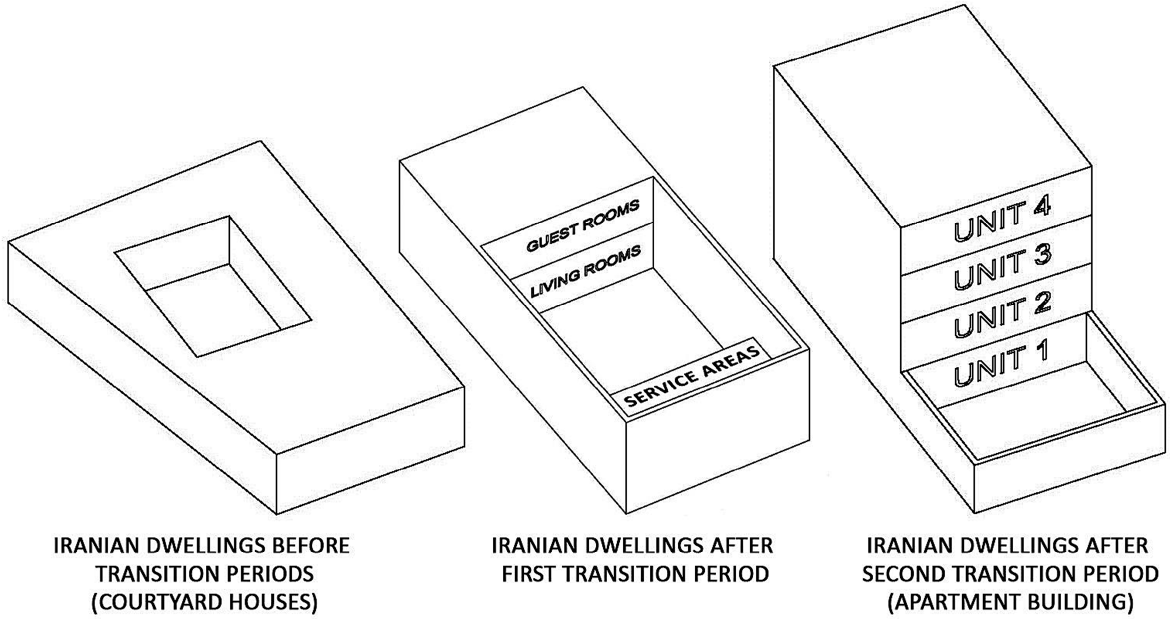

Figure 2-8: The transition of Iranian dwelling's structure during the first and the second period. Created by author

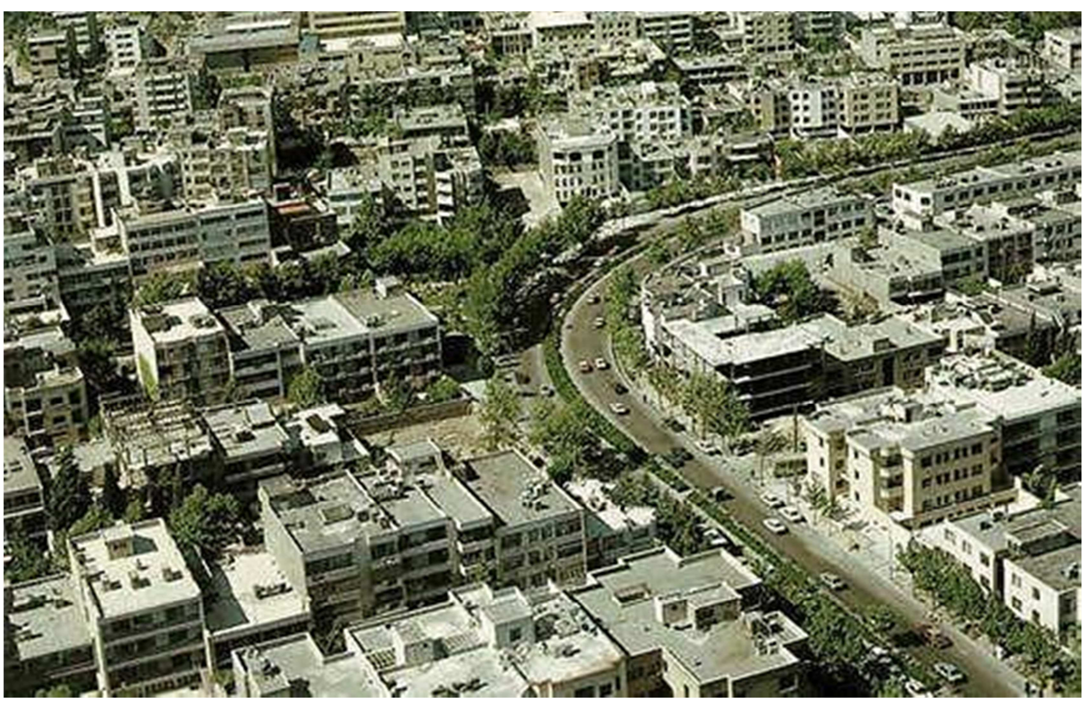

Figure 2-9: Iranidan dwellings in the comtemporay era

Figure 2-10: Contemporay residential texture, satalite view, Kashan, Iran

2.6. Courtyards and their Daylight Features

In terms of daylight and Iranian traditional houses, there is a correlation between daylight and courtyards, with the orientation and the layout of spaces in traditional houses as a direct response to climatic conditions. The intense sunlight meant that traditional houses were oriented along a north-south orientation. This north-south orientation of the courtyard derives principally from the need to control the natural light (Memarian & Brown, 2003).

Figure 2-11: The northern-southern orientation of courtyards, Kashan historic center, Iran. The figure shows that courtyards have followed mostly the same orientation in a specific region. Retrieved from www.maps.google.com

Figure 2-12: The northern-southern orientation of courtyards, enlarged satellite view, Kashan historic center, Iran. The orientation of courtyards has followed mostly a specific pattern. Retrieved from www.maps.google.com

The orientation allows the courtyard houses to have two different zones for using daylight: one is in the north side of the courtyard and other one is in the south. Rooms situated in the northern quarters of the courtyard face the south direction, receive more daylight; so, they are suitable for the dim winter days, being lit up by the winter sun. Conversely, rooms located in southern side face the north direction, receive less sunlight and are mostly in the shade (see Figure 2-13 and Figure 2-14) (Atefeh Zand Karimi, 2012; Memarian & Brown, 2003).

Thus, in north side of courtyard, all the openings in this side open directly to the courtyard; so the openings' surfaces received the most amount of sun light, while in the opposite side, openings were opened indirectly to the courtyard. As such, it was difficult to find a porch in the north side of the courtyard, while in the south side, a porch was often located in front of the rooms; this porch prevented direct sunlight from reaching to the openings (see Figure 2-13 and Figure 2-14).

Figure 2-13: The southern of courtyard, Bani-Kazemi house, Kashan city, Iran. Retrieved from Haji-Qassemi (1996)

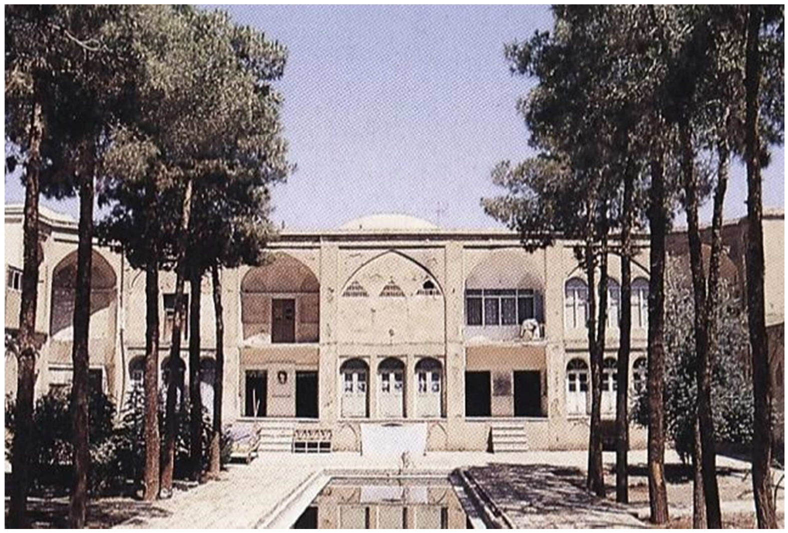

Figure 2-14: The northern side of courtyard, Bani-Kazemi house, Kashan city, Iran. Retrieved from Haji-Qassemi (1996)

In addition, the western side of courtyard which receive the sunlight from morning until noon was considered as a suitable place for locating rooms. On the contrary, the eastern part faced horizontal sunlight during the noon until sunset was considered for placing the service areas.

For controlling light entering into the rooms, typical wooden and brick lattice openings were used (see Figure 2-15, Figure 2-16, Figure 2-17and Figure 2-18). Each opening type has its owned characteristics and each played an important role in fragmenting the sunlight and making shadows. Furthermore, coloured glass was integrated into these openings to filter the daylight. The colour of the glass and the lattice geometry followed certain traditional patterns. Similarly, openings dimensions followed the same roles.

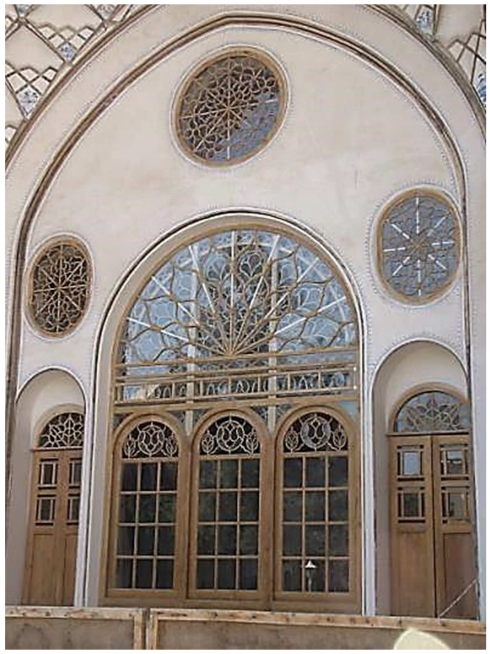

Figure 2-15: The exterior view of lattice and coloured openings, Ameri house, Kashan, Iran. Photo courtesy of the cultural heritage organization of Iran

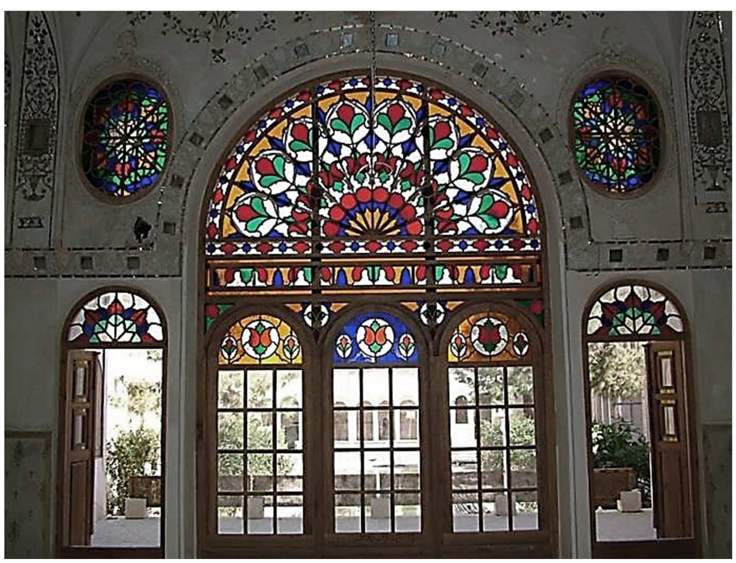

Figure 2-16: The interior view of lattice and coloured openings, Ameri house, Kashan, Iran. Photo courtesy of the cultural heritage organization of Iran

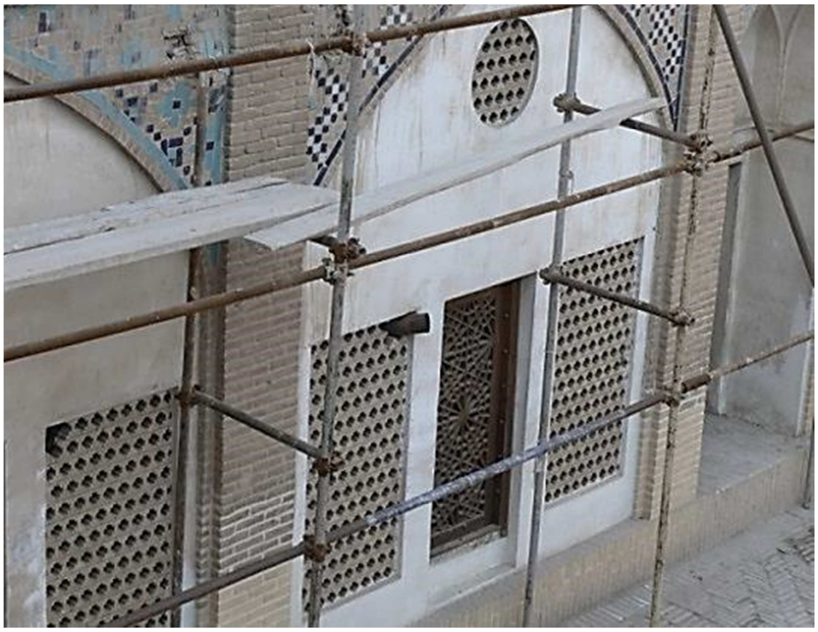

Figure 2-17: Wooden and brick lattice openings for preventing the penetration of direct sunlight into spaces. Photo courtesy of author

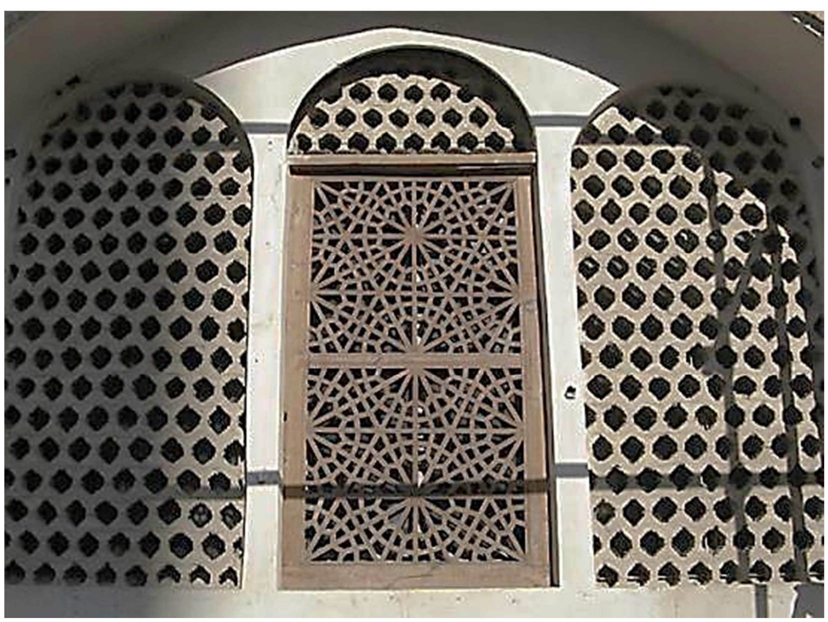

Figure 2-18: Wooden and brick lattice openings for preventing the penetration of direct sunlight into spaces. Photo courtesy of author

Architectural elements would act as deflectors to control the daylight that entering a space, as shown in Figure 2-19. Their depth depended on the type of space and its required daylight. In the north side of courtyard, because of user's need for receiving direct sunlight inside of the spaces, cannot find any light deflector; while, in the south side of courtyard, can easily find the openings that have deep light deflectors in order to prevent the direct sunlight from entering into spaces. Sometimes, based on the depth of light deflectors, small porches were formed in front of the openings.

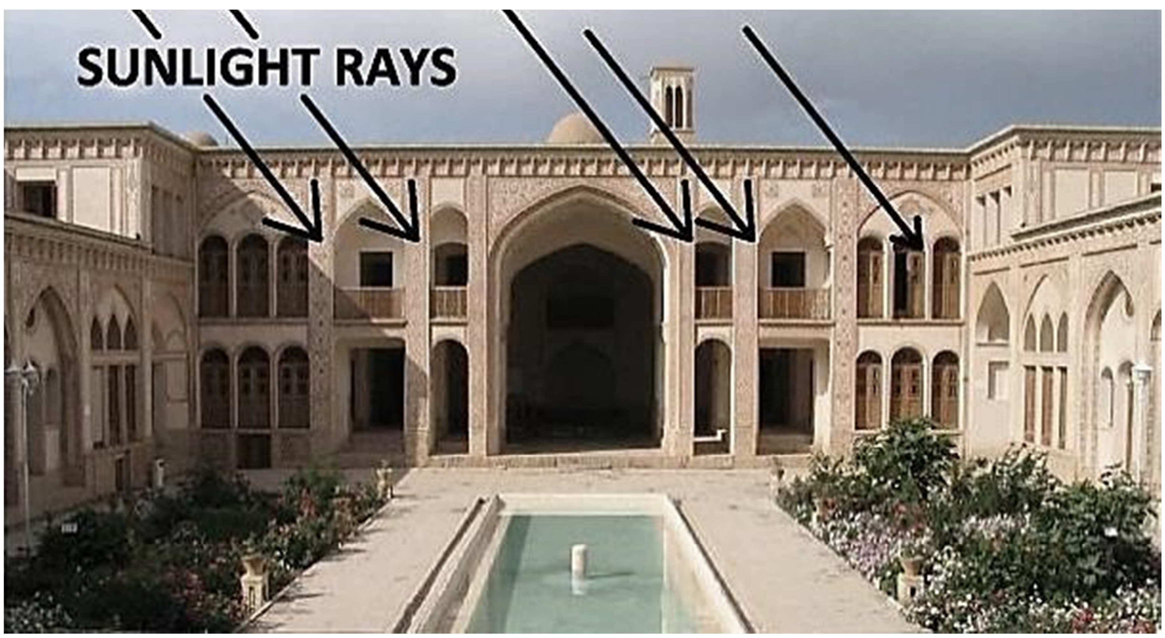

Figure 2-19: Sunlight deflectors, in the southern side of courtyard, they prevent from entering the direct sunlight into spaces, Ameri house, Kashan, Iran. Photo courtesy of the cultural heritage organization of Iran, edited by author

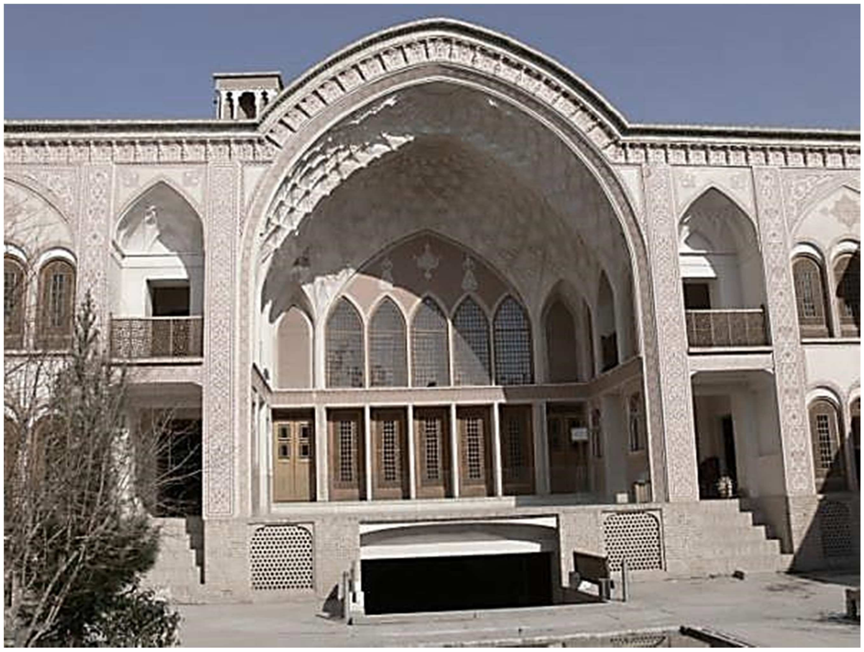

Figure 2-20: The northern face of courtyard , Ameri House, Kashan, Iran. Photo courtesy of author

Figure 2-21: The southern face of courtyard, Ameri House, Kashan, Iran. Photo courtesy of author

For controlling the daylight some other features were used too. For instance, a pool was located in the middle of courtyard in front of the northern part for reflecting the daylight in the spaces or vice versa. A second element for decreasing the light would be thick white cotton curtains, hung on the exterior façade over the openings for fragmenting the light. In addition, for preventing entering sunlight reflection to interior spaces a large part of courtyard was considered for planting plants and flowers (Arjmandi et al., 2011; Pirnia, 2008).

Figure 2-22: Pool and plants in front of northern side, Ameri house, Kashan, Iran. Photo courtesy of cultural heritage organization of Iran

Figure 2-23: Pool and plants in front of northern side. Photo courtesy of cultural heritage organization of Iran

The proportions are another feature. The preparation of the minimum required illumination even in the darkest sides was considered. The process of a daylight-based design in courtyard houses follows a modular design system and special units. Using a modular system in design of courtyard, rooms and openings has helped designers harmonize the daylight which was received. The units utilized in designing courtyard houses derive from human scale, such as the dimension from fingers to elbow in a medium size person or an open hand (Faezeh Nabavi, 2012; Vakili-Ardebili & Boussabaine, 2006).

Spaces dimensions in different sides of Iranian courtyard are based on providing the enough required illumination in the darkest sides of the space; by getting away from the lighting source (openings), the amount of light in the space will be reduced. By considering the horizontal sunlight penetration into the north side spaces (winter zone), spaces could be designed deeper than the spaces in courtyard southern side. Therefore, the rooms located in the north side usually have the bigger length and width than southern rooms. This relative enlargement of the spaces in the north side of courtyard (thanks to the possibility of enough light penetration in these spaces) responds well to Iranian user needs to the sunlight in the winter; in the course of dim winter days when the family members spend much time inside the spaces, these larger and lighter spaces will provide the required illumination as much as possible.

2.7. Daylight Modeling

Daylight modeling refers to a physical scale model or computer program calculation of daylight in a space, using specific sky scenarios, such as clear sky or overcast, or real world weather data files for a specific location. Historically, increasing the importance of using daylight in buildings, as a matter of comfort and well-being of occupants and energy efficiency, led to a vast attempt to evaluate and calculate the daylight in the buildings (Pereira & Guedes, 2012; VanZee, 2011).

2.7.1. Early Approaches to Measuring Daylight in Architecture

In 1966 book “Daylighting”, written by Hopkinson, Petherbridge and Longmore, they show complex procedures of daylight calculation in buildings. Shortly after in 1970, another document was published by International Commission on Illumination (CIE) on available daylight calculation methods, introducing more than fifty calculation procedures. Meanwhile, one of the methods most often used to calculate daylight distribution in buildings was the analysis of physical scale models, studied in an artificial sky simulator.

The analysis of physical scale models, as the oldest procedure for understanding and analyzing the daylight characteristics in the buildings, avoided usual laborious calculation procedures.

2.7.2. Emerging technologies for measuring daylight

But in the last few years, the technology development and advance of computer science led to using computer programs (software) to evaluate and to analyze daylight in buildings (Pereira & Guedes, 2012; VanZee, 2011). Here in Figure 2-12, we see two different tools which are used to evaluate daylight performance in buildings.

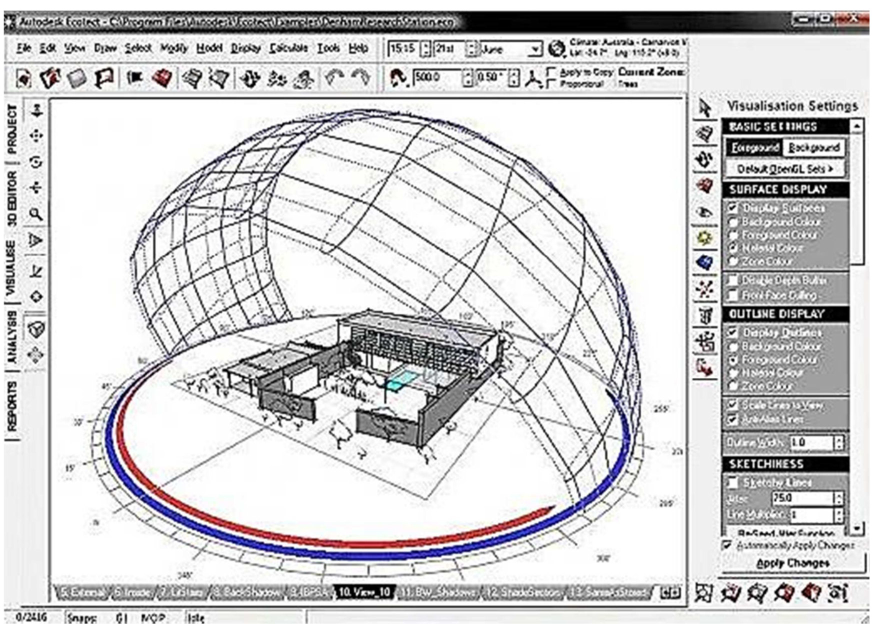

Figure 2-24: Ecotect Autodesk daylight analysis software. Retrieved from www.archdaily.com

Figure 2-25: Heliodon for daylight analysis with physical models. Retrieved from www.lipid.epfl.ch

2.7.3. Daylight Simulation Software

The first generation of daylight simulation software was only based on geometric design of a single space, rectangular, with a single window, designed for DOS, and the early days of Mac OS. Today available computer programs are capable of providing full reports on daylight within any type of space, under any sort of sky and in any geographical location, measured on a specific day and time. This method has revolutionized the analysis of daylight (Bryan & Autif, 2002; Pereira & Guedes, 2012). The most frequently used daylight simulation computer programs in literature are DaySim, Energy Plus, Google SketchUp and Radiance directed only for studying the daylight. Others like Ecotect and Design Builder perform also thermal and acoustic analysis.

According to a survey in 2006 conducted by Christoph Reinhart and Annegret Fitz, on the current use of daylight simulation programs in building design, they found seventy-nine (79%) percent of survey participants used daylight simulation. Among a total of one 134 participants in the survey, they reported using of 42 different types of daylight simulation programs (Hajjar et al., 2011). It illustrates vast variety and accessibility of daylight computer simulation programs (VanZee, 2011).

Summary

Briefly, in the past several decades, the morphological changes of Iranian houses, the advent of artificial lighting in Iran and the lack of knowledge about the important impacts of daylight on occupants' well-being have changed markedly daylight and its use in Iranian dwellings. As a consequence, the use of daylight and occupants' well-being that is related with it has been reduced. Considering the significance of daylight in Iranian traditional dwellings, in the next chapters, the research explores the possibility of extrapolating the traditional techniques of using daylight into Iranian modern dwellings in order to optimize the use of daylight and as a result occupants' well-being.

Finally, an introduction to modelling of daylight is presented and the computer programs and methods summarized. We turn next towards a presentation of the methodology used to explore the use of daylight in contemporary Iranian dwellings.

CHAPTER 3

3. Methodology

In the past few decades, morphological changes in Iranian dwellings and the increased use of artificial lighting in houses have led to a decrease in the use of daylight. This affects the occupants' well-being in terms of a diminished access to daylight relative to how daylight was used and experiences in traditional Iranian houses. We have just seen in Chapter 2 how actual harnessing of daylight was successfully done in traditional architecture through orientation of houses, strategic location of windows and positioning of various elements to capture daylight. Consequently, there is value in using daylight ideas from Iranian traditional dwellings, and to understand them in terms of how daylight was used as the principal source of lighting. The researcher has studied the techniques of using daylight in traditional dwellings as a guide to extrapolate its positive aspects, and then suggest possibilities in terms of daylight for modern residential dwellings.

In terms of methodology, a multiple case study of three Iranian traditional houses will be conducted using three specific traditional Iranian houses. This multiple or collective case study is conducted based on a constructivist paradigm (Baxter & Jack, 2008; Noor, 2008; Stake, 1978; Zainal, 2007). The constructivist paradigm claims that truth is relative and it depends on one's perspective. From this stance, the research aims to elicit and understand separate meanings to construct shared meanings around the phenomenon of interest based on the researcher's interpretation (Baxter & Jack, 2008; Lauckner, Paterson, & Krupa, 2012; Mills, Bonner, & Francis, 2006). In terms of this research study, an understanding of techniques of using daylight in traditional dwellings is conducted in three separate traditional houses, these techniques of using daylight were studied, and finally shared techniques were extracted in order to be extrapolated into modern dwellings to optimize the use of daylight and as a result to enhance occupants' well-being. If we recall the principal question of this study: How to enhance well-being in Iranian modern dwellings through studying the techniques of using daylight in traditional houses?

Furthermore, in this research, for confirming and supporting the research questions, a survey questionnaire was conducted before doing the case study. Through the survey questionnaire, Iranian experts' viewpoints about the main subject were collected and the shared issues were extracted. Then, in the last stage, through computer daylight simulation of three different traditional courtyards, daylight effects are analyzed and evaluated. The emergent themes are compared to the extracted data of literature review and survey questionnaire to find out which one is more or less important. With use of these three documented aspects in this study, the salient issues, themes or ideas concerning the use of daylight in traditional houses will be extrapolated and then considerations applied to the design of modern dwellings.

3.1. Research Study Site Location

The context of this research is Kashan city[2] in central desert of Iran. This site was chosen due to the rich historical texture that still remains there in spite of all reconstruction (or destruction) has happened during the last decades in all cities of Iran. The chronological context of this study is in Qajar period; in fact, the turning point in Iranian architecture happened in this time. Indeed, in the Qajar dynasty (1794-1925) contacts between Iran and the West increased. The

[2] The selection of this city is explained in 3.3

intensification of Iran's contact with the Western countries and the acquaintance with the industrial and economic development of these countries which have led to growth in all aspects and fields in the West has encouraged Qajar princesses and authorities to follow a series of wide spread social and cultural changes in Iran with following what has existed in the West. Subsequent social and cultural reforms have caused principal structural changes in Iranian big cities. In the meanwhile, the preliminary stage of Iranian modernism took place during this period, and influenced on many areas of life such as architecture (Bani Masoud, 2009; Diba & Dehbashi, 2004; Ghobadian, 2010; Micara, 1999).

The chosen case study has focused only on Iranian traditional courtyards in part, due to the Iran's climate, being mostly arid or semi-arid and that courtyard houses were the prevalent housing-type of this region. Since the analysis of the all parts of these houses is impossible through a master's thesis project of this type, the choice was made to select winter living rooms for this study. This choice has based on the following considerations: 1. the results of the survey of Iranian experts (questionnaire) have revealed the importance of using daylight in living room, 2. The literature review of courtyards indicates that there were two types of living rooms in these houses; one was used in summer and other one during winter; and 3. The literature review also has shown that winter living rooms were used during the dim winter days when there the worst daylight conditions exist, and therefore benefiting from daylight has the greatest importance.

In the next phase of study, three winter living rooms were chosen among nineteen courtyards that are registered by the Iranian cultural heritage organization. The selected winter living rooms all have the feature that they benefit from the daylight through their northern and southern openings. Finally, the 3 selected cases are analyzed by daylight simulation software and models are created by the researcher to compare the amount of daylight in these three cases with the Iranian lighting standards of living rooms in residential buildings.

3.2. Questionnaire

The paper-based questionnaire consists of 9 open-ended questions that were created to understand the Iranian experts' viewpoints concerning the significance of daylight in traditional courtyard houses to solve a part of the current problems in the design process of Iranian dwellings, and consequently optimize the use of daylight and enhance occupants' well-being in housing sector. The questions are arranged in three principal categories: 1. Personal experiences; 2. Current situation of dwellings; and 3. Traditional residential building.

Indeed, considering the central core of this study that was focused on optimizing the use of daylight in residential buildings, the questionnaire is organized in three parts. The first part asks generally about the importance of using daylight in the design process of Iranian dwellings. In the second part, considering the current problems in terms of using daylight in dwellings that decreased well-being, questions are about the existing problems and potential solutions. This part aims to reveal the problems and to state the possible solutions. Finally, as the research attempts to respond to the principal question of this study, the last part contains questions about the significance of daylight in Iranian traditional houses and the possibility of extrapolating the traditional techniques of using daylight into modern dwellings as a probable solution for current crises.

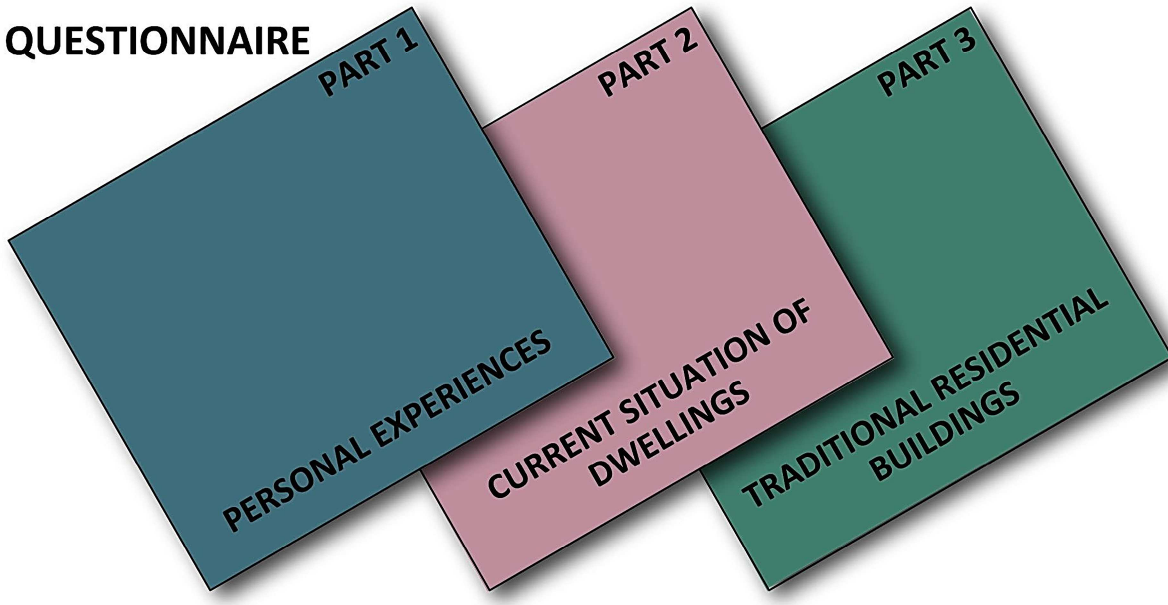

Figure 3-1: Questionnaire parts. Source: Created by author

3.2.1. The Questionnaire Elements

In terms of detail, in the first part of the questionnaire, the participants were questioned about the importance of using daylight in the designs process of residential buildings in Iran. Three questions have placed in this part. The purpose of the first question was to understand the importance of using daylight in design of residential buildings from the participants' viewpoint: *What is the position of the natural lighting in your design for a residential building?*

The second question was asked in order to find out experts' opinion about how much the use of daylight is important in the design process of dwellings: *What is the priority that you consider for the natural lighting in designing a dwelling?*

Finally, based on the importance which the participants have considered for using daylight in the design of residential buildings, they were asked about positive and negative aspects: *With regard to using natural lighting in your projects, could you mention to weaknesses and strengths in some cases?* Furthermore, in this question the participants were asked to provide some examples: *Please attach related documents and photos?*

In the second part of the questionnaire, the participants' opinions about the current problems in the design of the residential building relating to the use of daylight were questioned and they were asked to suggest possible ways out. The second part contains three questions: the first question asks the participants to indicate the limitations that they confront in the design process of Iranian dwellings that brings current problems in terms of using daylight. Thus, the first question is: *Could you mention to limitations that you may face in Iran for using the natural lighting in designing of a today dwelling in terms of building codes and cultural norms and etc.?*

In the second and the third questions, participants were asked about the potential solutions. The second and the third questions are respectively: *By considering the mentioned limitations, what are your suggested ways for benefiting from natural lighting in today residential building?* And *what are the possible solutions for using natural lighting in today's dwellings?*

Finally, in the last part of this survey, the questionnaire was directed toward asking about the significant of using daylight in traditional houses and the possibility of extrapolating traditional daylight techniques as a pattern in the design of modern dwelling in order to optimize the use of daylight and as a result to enhance well-being. This part has consisted of four questions: the first question has asked participants to indicate how much they are familiar with the traditional dwellings: *How much knowledge do you have about Iranian traditional residences?*

Based on the participants' background knowledge about traditional dwellings, they were asked to mention that how much traditional dwellings were succeeded in terms of using daylight. Then, they were asked about the possibility of using techniques of using daylight in the traditional houses as a sample or pattern in order to optimize the use of daylight in modern dwellings: *How successful do you consider traditional residential buildings for methods that they used to provide benefits from natural lighting and could these methods be used in today's residential architecture for solving daylight problems?*

In the next question, the participants' viewpoint were asked about the extrapolation of the methods of using daylight in traditional houses into modern residential buildings as probable option for solving current problems: *As an Iranian contemporary architect, do you consider the traditional methods of using the natural lighting as one of the options on the table for solving the current problems?*

Finally the participants were asked to criticize contemporary residential samples which have used daylight according to the traditional pattern of using daylight: *Could you mention to some examples among today designed residential building that using the natural lighting was done by regarding the traditional methods? Please criticize some of these examples?*

The survey questionnaire was conducted in collaboration with WTIA University[3] in Iran. Therefore, on advice of the Dean[4] of WTIA University (Dr. Dolatabadi) who is personally architect and academic, the questionnaire (see Appendix IV) was distributed among 8 professors at this university. These participants are well-known architects, who are involved in academia and in designing residential apartments in Iran.

To assure complete confidentiality, and as the information that each participant has provided is kept completely confidential, each participant was assigned a number and only the principal researcher has the list of participants and the numbers that were assigned.

The consent form and the questionnaire were sent to Dr. Dolatabadi (the research collaborator in Iran) via email. The consent form and the questionnaire were then distributed respectively to the 8 participants. The consent form was sent for each participant three days in advance. Thus, the participants have had three days for reading the conditions of participation in the research and contacting the researcher through email or by phone for asking further inquiries. Dr. Dolatabadi collected the signed consent forms and also then distributed the questionnaire. The participants have had five days to answer the questions and to give it back to Dr. Dolatabadi. Then, the signed consent forms and filled questionnaires were collected by Dr. Dolatabadi, scanned and sent to researcher via email.

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[3] West Tehran Islamic Azad University
[4] Fariborz Dolatabadi, Ph.D. in Architecture,
the current dean of WTIA University and
the previous deputy for Iranian cultural heritage

3.3. Case Selection

In this next section, the selection procedure of traditional courtyard houses will be explained step by step. Cases (selected courtyard houses) were chosen based upon criteria such as the historic context where they were located, and the era when they were constructed. Furthermore, accessibility to architectural drawings and images was also another influential factor in the selection process.

3.3.1. Iran Historic Centers

The historical center of each Iranian old city has comprised the most precious architectural monuments. The historic center of each Iranian old city is the oldest nucleus of that city which has evolved over centuries. The old cities of Iran, located in hot-arid region, have contained the valuable samples of traditional courtyard houses (Moosavi, 2011b). Therefore, the first step is to find a historic center in a hot-arid region of Iran where the required traditional courtyard houses were located. The organization of cultural heritage of Iran have registered historical center of 90 cities with a total area of 16000 hectares (Moosavi, 2011a).

Since, Iran's climate is mostly arid or semi-arid and traditional courtyard houses were the prevalent traditional housing-type of this region (A'zami et al., 2005; Bahrami, 2008; Zaimi, 2010); this research was focused on studying daylight in traditional courtyards. Figure 3-4 has illustrated a comparative summary of data on the historical centers of some important cities in Iran. Cities which were situated in the hot-arid region were highlighted: Isfahan, Yazd, Shiraz and Kashan.

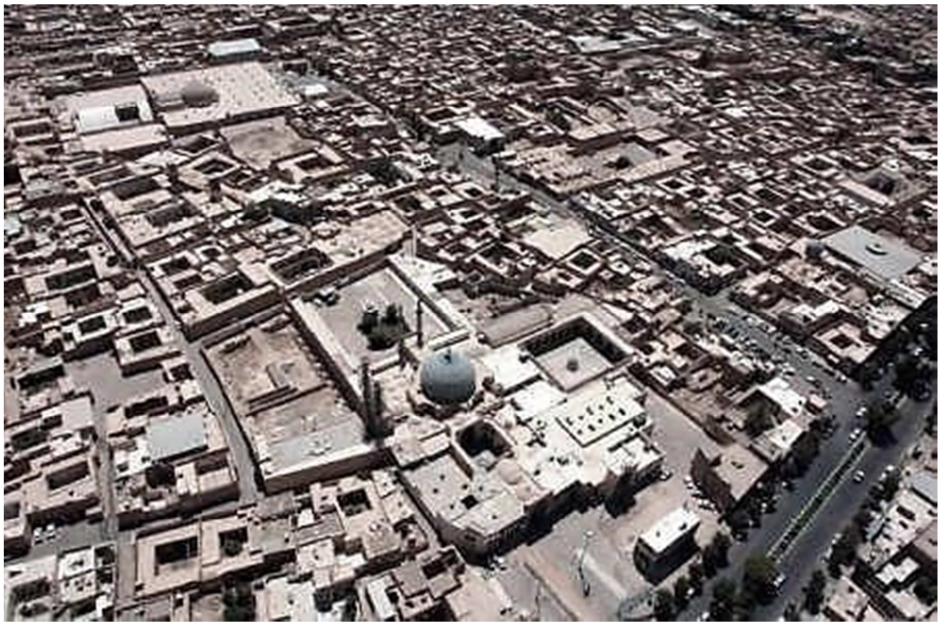

Figure 3-2: Historic Centers of Yazd city. Retrieved from www7.yazd.irna.ir

Figure 3-3: Historic Center of Isfahan city. Retrieved from www7.yazd.irna.ir

City	Area of Registered Historic Center (hectare)	Percentage to Total Area of the City
Ahvaz	95	5 %
Brujerd	280	6.5 %
Bushehr	350	2.5 %
Dezfool	500	7.5 %
Ghazvin	100	2.5 %
Isfahan	1200	9.2 %
Kashan	600	35 %
Mashah	1500	7.5 %
Rafsanjan	21	2 %
Sanandaj	90	2.5 %
Shiraz	375	3 %
Tabriz	421	3.5 %
Urmieh	417	3 %
Yazd	730	15 %
Zanjan	83	1 %
Zavareh	6	12 %

Figure 3-4: Iran's registered historic centers. Retrieved from Moosavi (2011a)

In contemporary era, the historical centers of many Iranian old cities were destroyed by urban developments. These urban changes have occurred more seriously and broadly in metropolises such as Isfahan, Yazd and Shiraz (Alizadeh, 2005; Sharifi & Murayama, 2013). Kashan as a smaller city has experienced fewer urban changes in its historical texture. Therefore, among these four cities, Kashan is selected as the historic context for this research because of its relatively unspoiled historical texture.

3.3.2. Kashan City

Kashan city is situated in the north of the province of Isfahan runs along the edge of the central deserts of Iran. Its charm is because of the contrast between the parched immensities of the deserts and the greenery of the well-tended oasis. According to the census in 2006, population of Kashan is 248,789 people spread over an area about 5000 square kilometer (Daryabari & Ebrahimi, 2010; Zare, Kaboli, & Farhadian, 2013). Figure 3-5 has shown the province of Isfahan on map of Iran which was enlarged on right. The locations of Kashan commune and Kashan city were highlighted on the enlarged image of the Isfahan province.

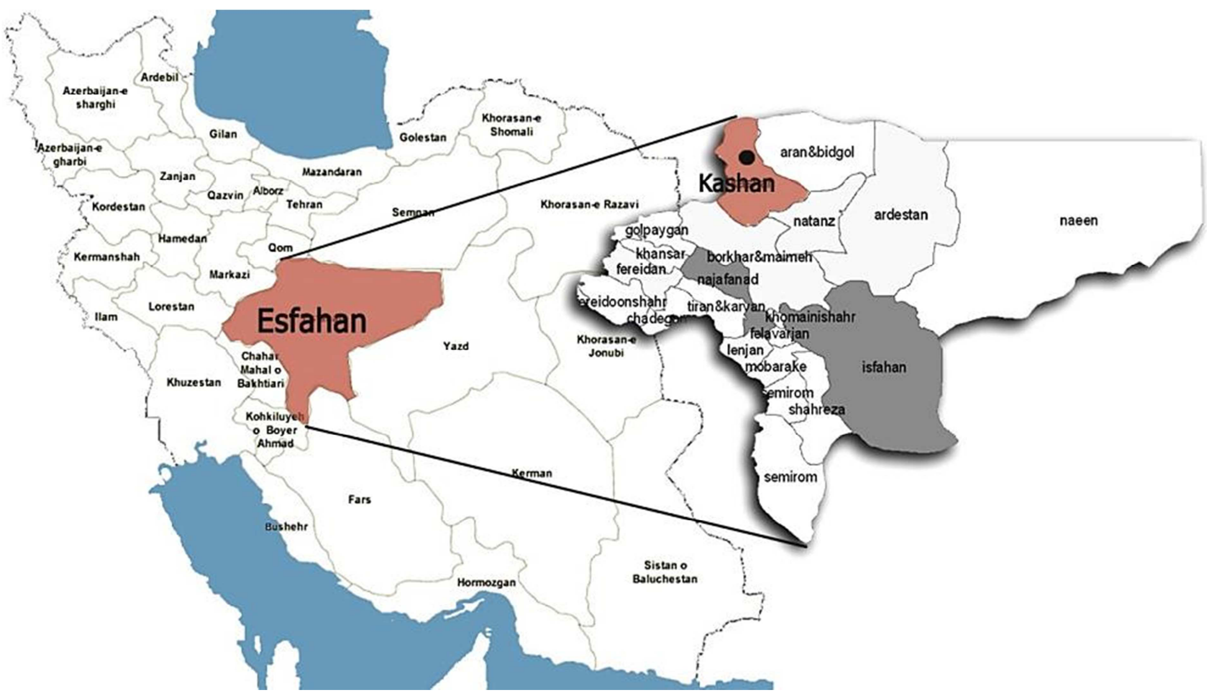

Figure 3-5: The location of Kashan city in Iran and in Isfahan province. Created by author

Kashan is situated in a hot-arid climate which is characterised with very hot summers, cold winters and a high temperature difference between day and night. For instance, according to climatic data registered in 2010, minimum temperature in winter was -5°C and maximum temperature in summer was 45°C. The climatic information of Kashan is shown in Figure 3-6 (Atefeh Zand Karimi, 2012; Taleghani, Behboud, & Heidari, 2010).

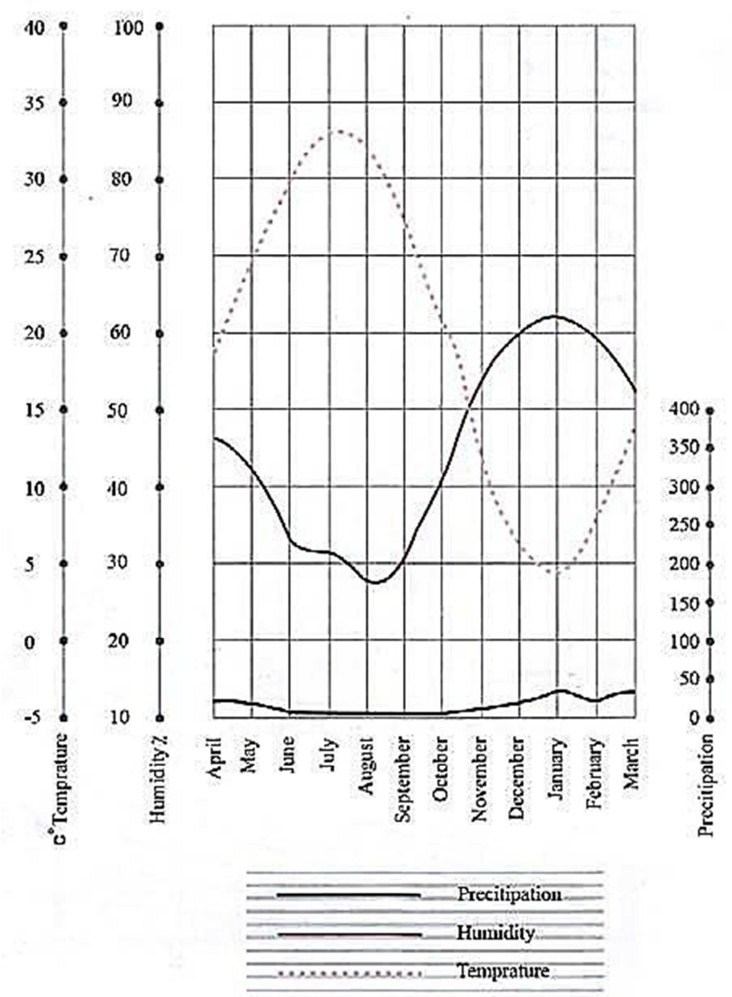

Figure 3-6: Kashan climatic information. Retrieved from Taleghani et al. (2010)

The history of Kashan dates back to prehistoric times. Kashan as one of the archaic cities of Iran was a place for people of various ethnicities to live like Sialk known as one of the oldest civilizations in the Central Plateau (Haeri, 2012). Kashan in different historical periods was a prosperous and affluent city that has caused to make a traditional and stable context.

The old Kashan city was changed and developed during last decades (Haeri, 2012). Thus, recognizing the old historic center of Kashan in today Kashan seems quite difficult. According to authorities and experts in cultural heritage organization of Iran, the historic area of today Kashan was identified and shown in Figure 3-7 (Varesi, Zangiabadi, Vafaei, & Gholami, 2013; Zangiabadi & Vafaei, 2010).

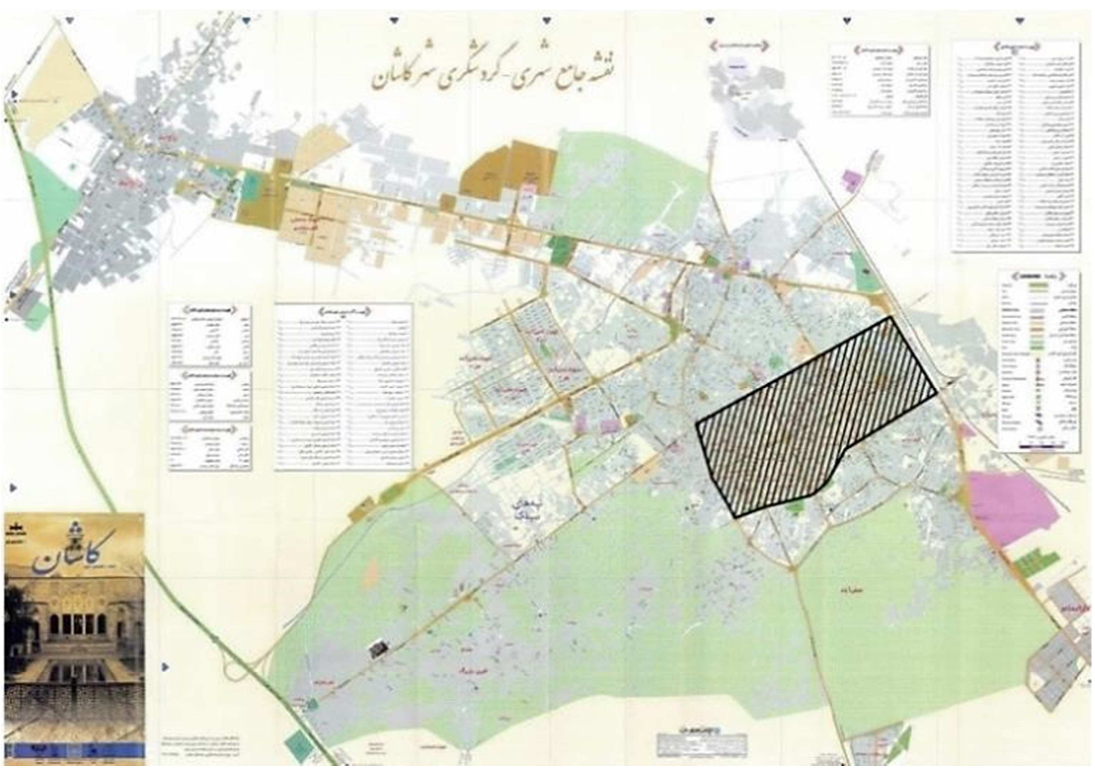

Figure 3-7: Kashan’ historic center . Retrieved from www.darman.kaums.ac.ir

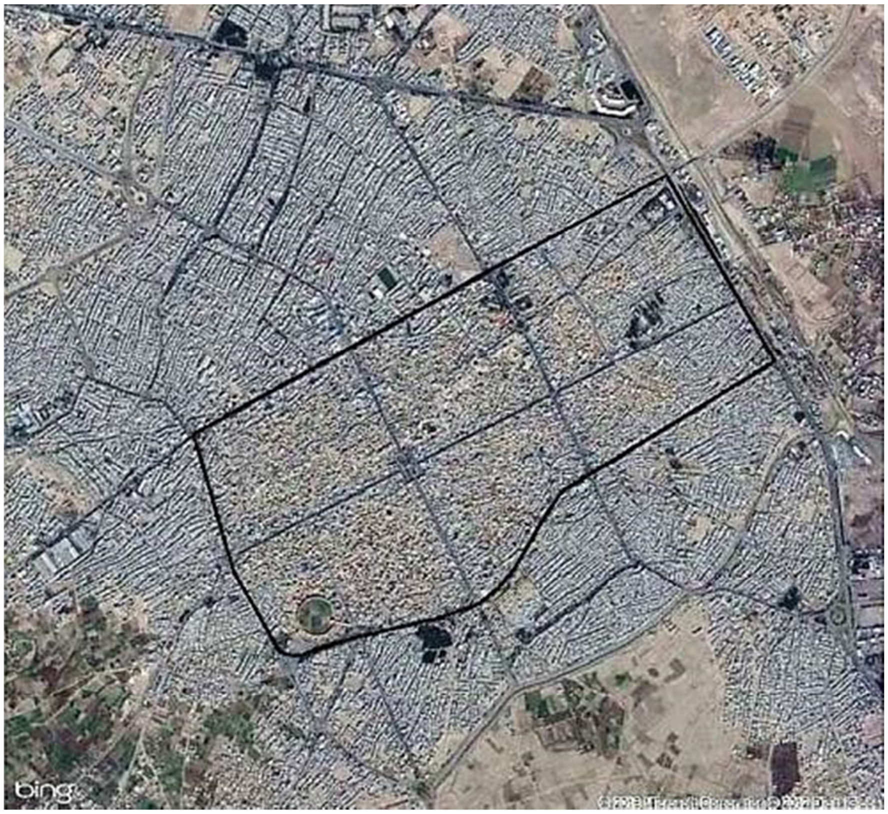

Figure 3-8: Kashan' historic center . Retrieved from www.maps.google.com and edited by author.

Kashan Traditional Courtyards

Kashan city boasts at least nineteen traditional courtyard houses that were well renovated and registered by the cultural heritage organization of Iran; they all were presented in the first volume of an encyclopaedia called Ganjnameh by Haji-Qassemi (1996). Undoubtedly, analyzing all parts of these historic courtyard houses requires a large amount of time and it is absolutely impossible through this thesis. Therefore, this research will be conducted particularly on one part of these houses.

Figure 3-9: Kashan’s historic context. Retrieved from www.archnet.org

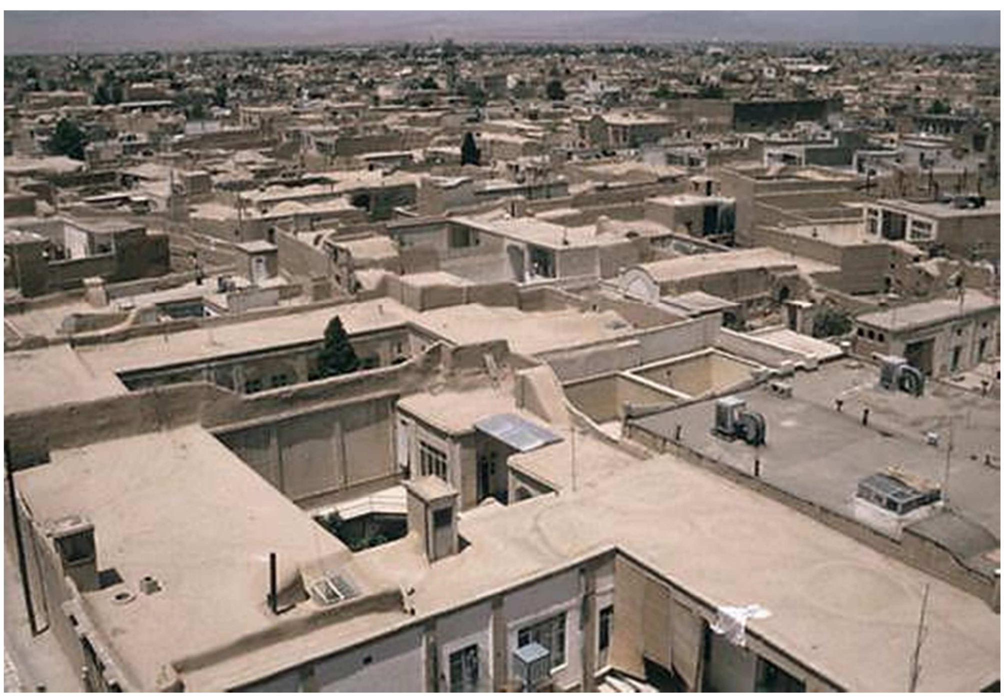

Figure 3-10: Kashan’s historic context. Retrieved from www.archnet.org

Figure 3-11: Kashan’s historic context. Retrieved from www.archnet.org

Winter Living Room

According to the result of the survey of Iranian experts (see 4.1), using daylight in living rooms during winter days has priority. Furthermore, as it was shown through the literature review, the historic courtyards have had two principal seasonal living rooms: one was used in summer and another during winter. In addition, the literature review has shown that the winter living rooms was used in dim winter days when there are the worst daylight conditions. In this worst daylight condition, the best measures must have been taken into winter living rooms to capture daylight as much as possible. Thus, it can be the best base to study the significance of daylight in Iranian traditional courtyards. Through this research, the winter living rooms of traditional courtyard houses were analyzed as a selected cell to study. The winter living room is one of principal parts of courtyard houses; it was located in the middle of northern quarter in courtyard on longitudinal and faced south (see Figure 3-12).

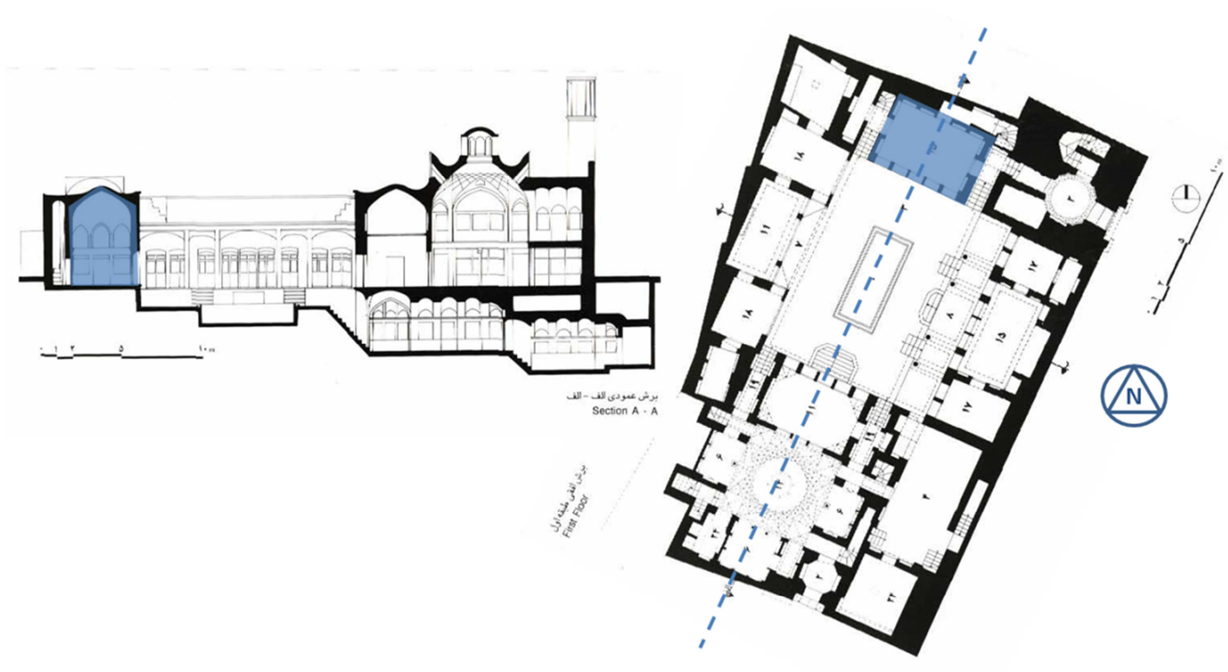

Figure 3-12: The location of winter living room in plan and section marked in blue, Jahan-ara'I house, Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

3.3.3. Selected Cases

As studying and analyzing daylight in the winter living rooms of all of 19 traditional houses has needed enormous time that was impossible through this master thesis. Therefore, the 19 houses were reviewed and 3 houses were selected as they have similar daylight patterns that could be compared (having openings in two sides). These courtyard houses were selected as the symbol of numerous precious traditional courtyard houses in Kashan and that use similar daylight patterns. Briefly, these houses were 3 of the oldest and well-known traditional houses in Kashan. According to the reports of cultural heritage organization of Iran, these houses have belonged to Qajar era. Iran was ruled by Qajar dynasty from 1794-1925. Figure 3-13 has shown the locations of these houses in historic center of Kashan city. The 3 selected houses are introduced below:

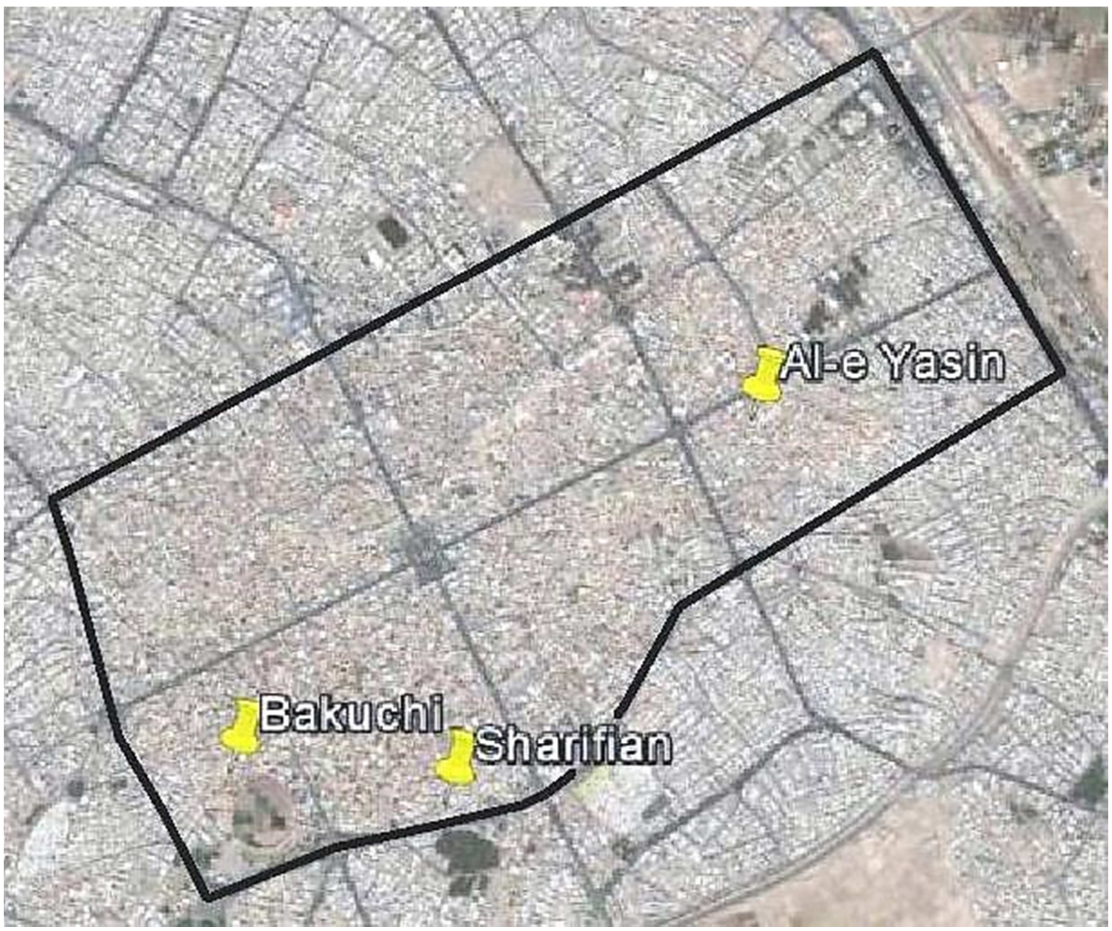

Figure 3-13: The location of selected houses in Kashan historic center. Retrieved from www.maps.google.com and edited by author.

Case No. 1 (Al-e Yasin House)

It was located in an irregular land plot, although it has followed a perfect geometry. The house has comprised a principal northern part with a backyard in the center, and two symmetrical eastern and western parts. (Haji-Qassemi, 1996). The southern front only has featured a wall faced with arcade. At the center of northern front, a domed backyard was situated. It was enclosed on four sides by rooms, all of which have opened toward the backyard. The winter living room was located in the southern side of the backyard and has overlooked the main courtyard of the house. This room has had a high ceiling and rise to a height of two stories. Figure 3-16 has shown the location of the winter living room in Al-e Yasin house which was highlighted in blue.

Figure 3-14: The northern side of courtyard, case no. 1 (Al-e Yasin house), Kashan, Iran. Retrieved from Haji-Qassemi (1996)

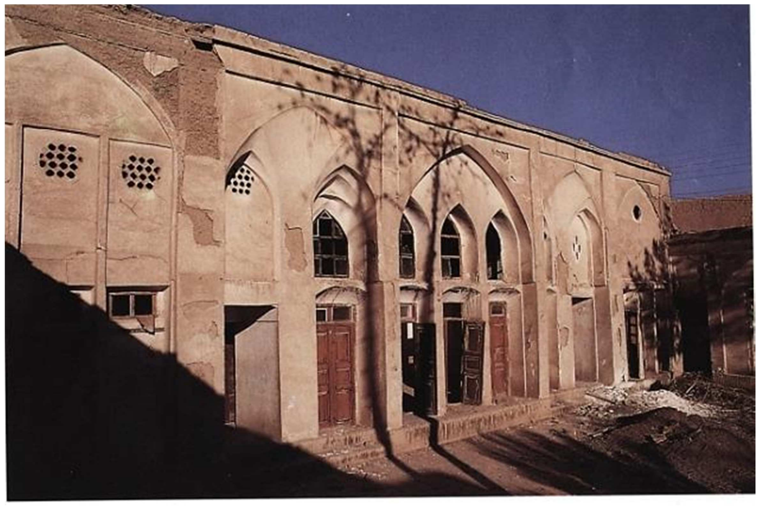

Figure 3-15: The northern side of courtyard, case no. 1 (Al-e Yasin house), Kashan, Iran. Retrieved from Haji-Qassemi (1996)

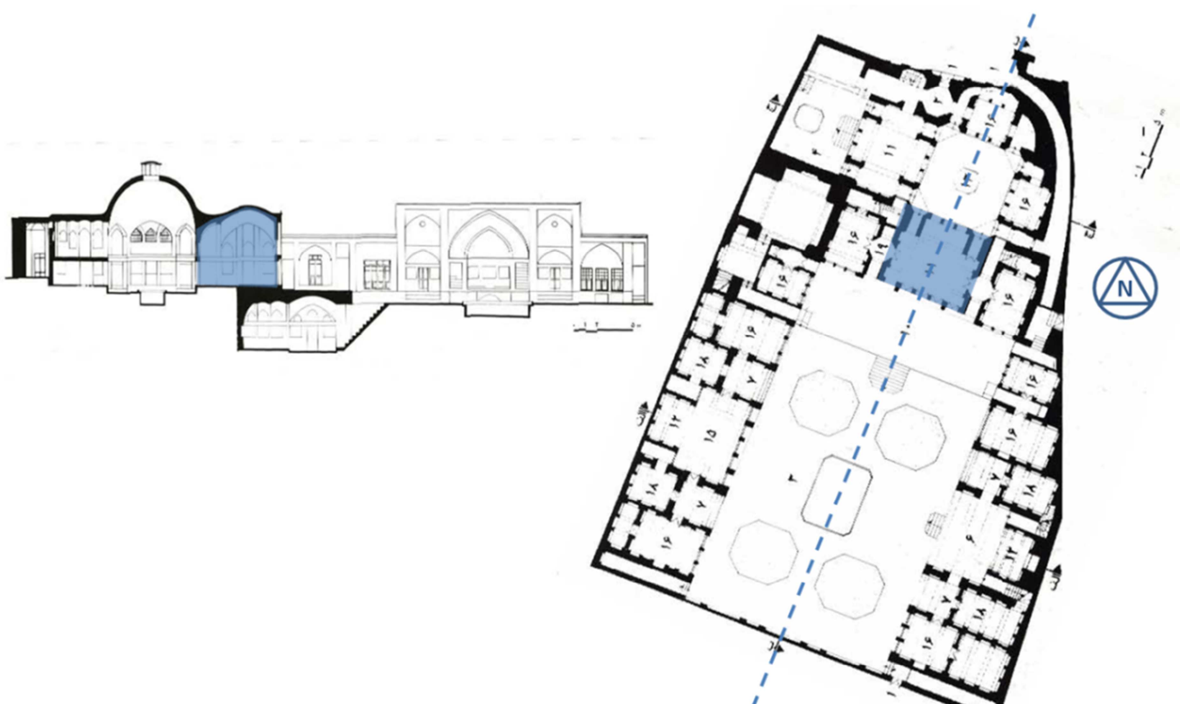

Figure 3-16: The plan and section of case no. 1 (Al-e Yasin house), Kashan, Iran. The location of winter living room marked in blue. Retrieved from Haji-Qassemi (1996) and edited by author.

Case No. 2 (Bakuchi House)

It has comprised of a rectangular courtyard with two spatial parts on south and north. The courtyard of the mansion was deposed on two levels. The most important part of the house has stood on the northern front with an octagonal backyard in the center to which spaces open from the south, west and east. On the southern side, the winter living room was located which also has opened towards the main courtyard from another side. Hence, the winter living room was lit by daylight form the backyard and the courtyard (Haji-Qassemi, 1996). Figure 3-19 has shown the location of winter living room on the northern part which was highlighted in blue.

Figure 3-17: The northern side of courtyard, case no. 2 (Bakuchi house), Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

Figure 3-18: The southern side of courtyard, case no. 2 (Bakuchi house), Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

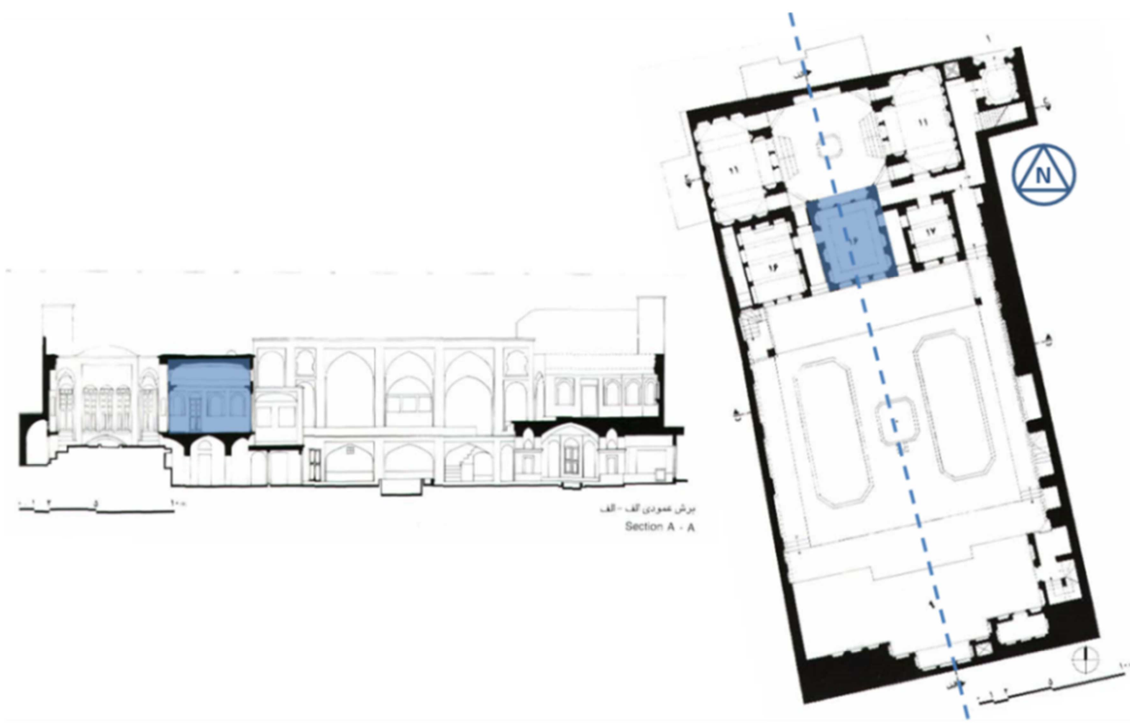

Figure 3-19: The plan and section of case no. 2 (Bakuchi house), Kashan, Iran. The location of winter living room marked in blue. Retrieved from Haji-Qassemi (1996) and edited by author.

Case No. 3 (Sharifian House)

The construction of this building dates back to 1814. The building was a composition of three spaces that has constituted northern, eastern and southern fronts of the courtyard. The winter living room on northern front of courtyard has occupied a central position. It has opened toward both the courtyard and a covered backyard which was located behind (Haji-Qassemi, 1996).

Figure 3-20: The southern side of courtyard, case No. 3 (Sharifian house), Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

Figure 3-21: The northern side of courtyard, case No. 3 (Sharifian house), Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

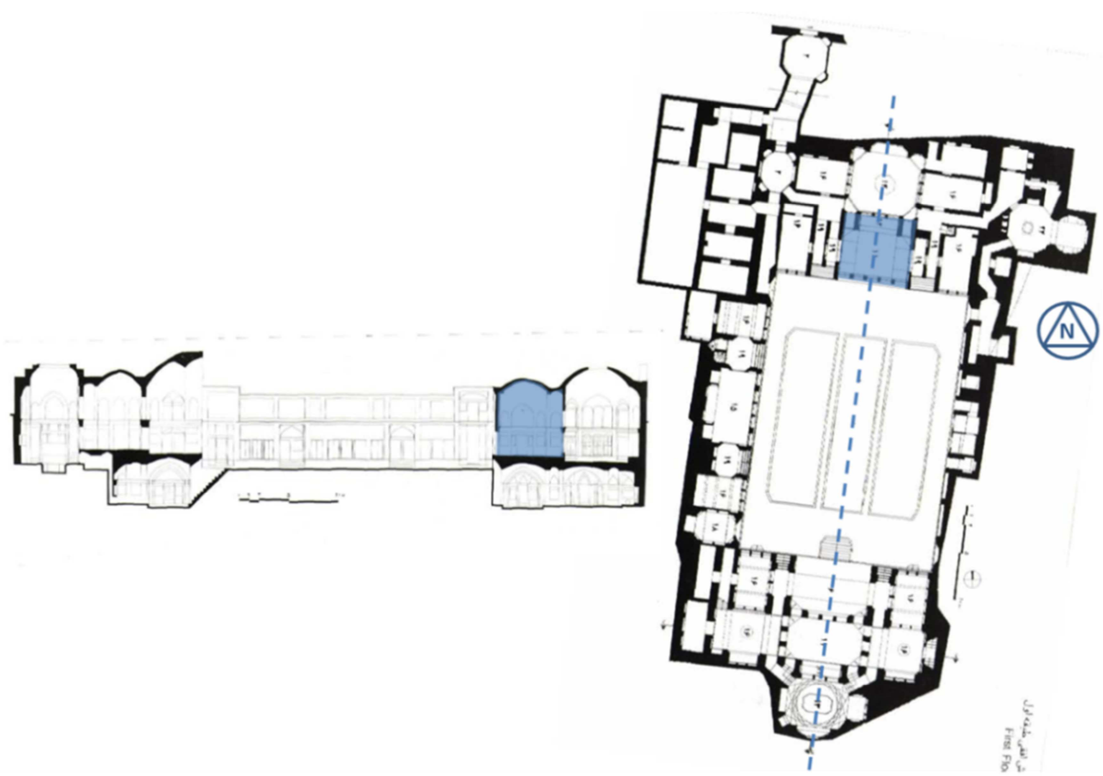

Figure 3-22: The plan and section of case No. 3 (Sharifian house), Kashan, Iran. The location of winter living room marked in blue, Kashan, Iran. Retrieved from Haji-Qassemi (1996) and edited by author.

3.4. Computer Daylight Simulation

The selected cases were modeled within computer modeling software and redirected to the simulation software for conducting daylight analysis. For more accurate simulation results, several factors were taken into consideration, such as orientation, all significant neighbouring and etc.; all these factors have impacted on the amount of available daylight in each specific case.

In this study the virtual tri-dimensional models were made in Autodesk AutoCAD, for its simplicity and accuracy in creating tri-dimensional models and furthermore for the possibility of exporting models to other design software with the least amount of errors in scale or significant changes.

In the first step, the required architectural drawings and images were gathered from the archive and photo courtesy of the Iranian cultural heritage organization. Since the drawings were in jpeg format, the required architectural drawings for doing the modeling were drawn two dimensionally and then these two dimensional drawings were used as a base for tri-dimensional modeling (see Figure 3-23, Figure 3-24 and Figure 3-25). The modeling process was very complicated and time-consuming due to the structural complexity of models in terms of geometry includes domes and arcs.

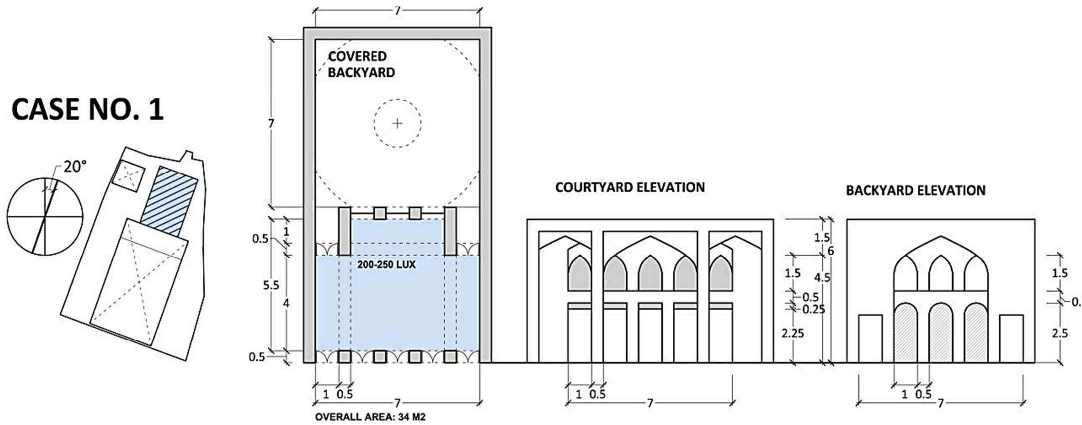

Figure 3-23: Two dimensional drawings, case no. 1. Drawn by author

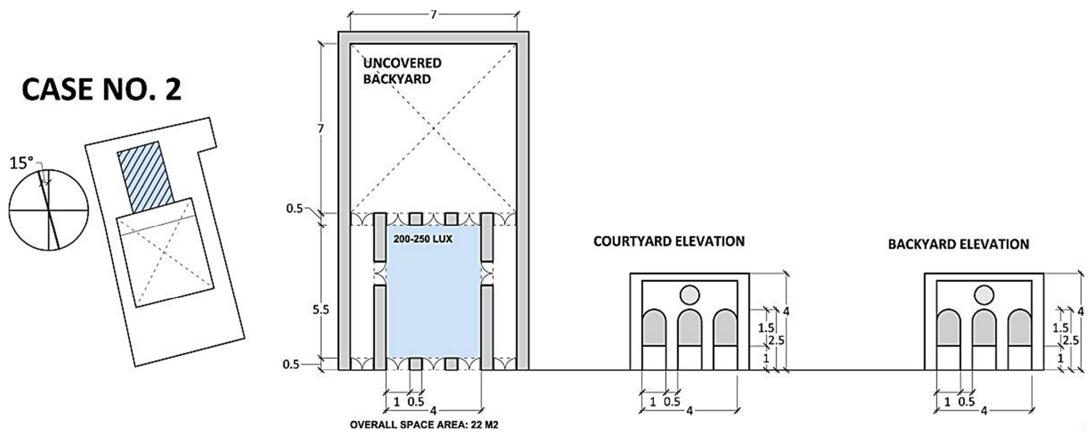

Figure 3-24: Two dimensional drawings, case no. 2. Drawn by author

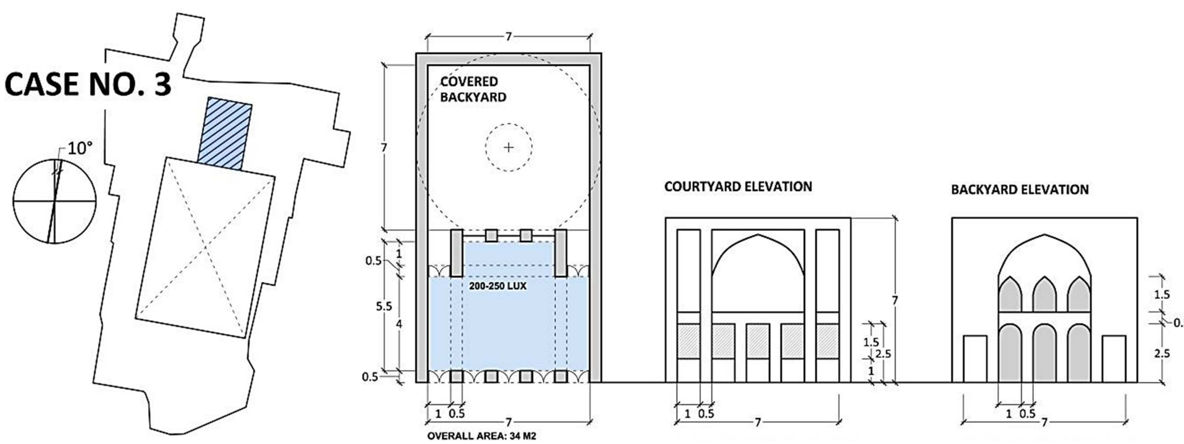

Figure 3-25: Two dimensional drawings, case no. 3. Drawn by author

To increase accuracy of results in analysing and evaluating of daylight in each case, the adjacent volumes were created solidly. The final result was a presentation of the principal space, the winter living room, which was modeled in details among the overall structure (neighbouring areas) of each courtyard. This phenomenon was very influential in analysis of daylight because of sunlight reflections from the adjacent walls and penetration of these reflections into the main space. Finally the modeled cases were rendered through AutoCAD. The renders were shown below in Figures 3.26 – 3.34.

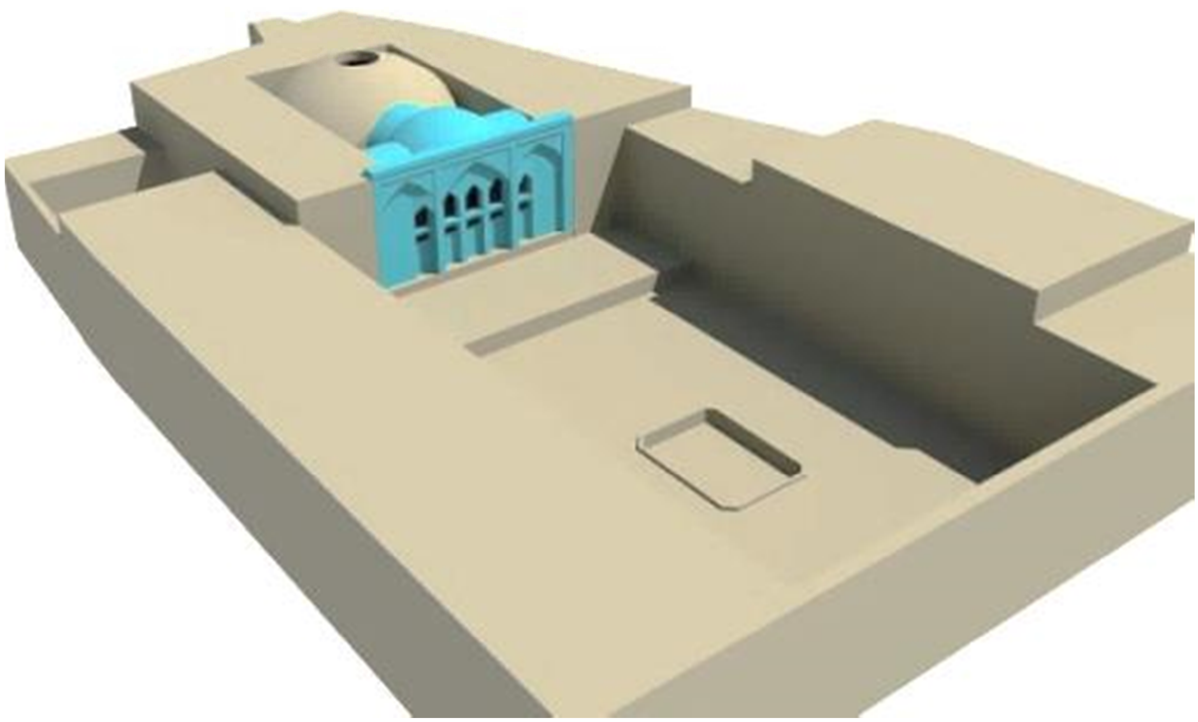

Figure 3-26: Computer modeling, case no.1. Created by author

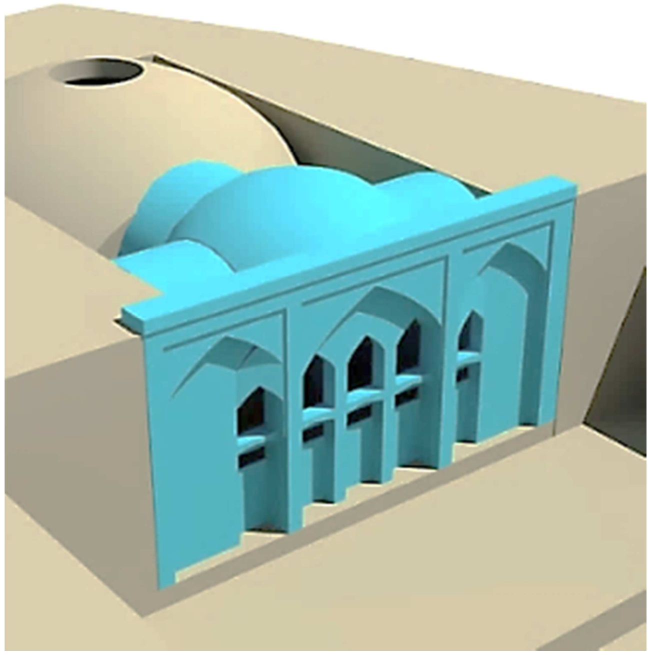

Figure 3-27: Computer modeling, case no.1. Created by author

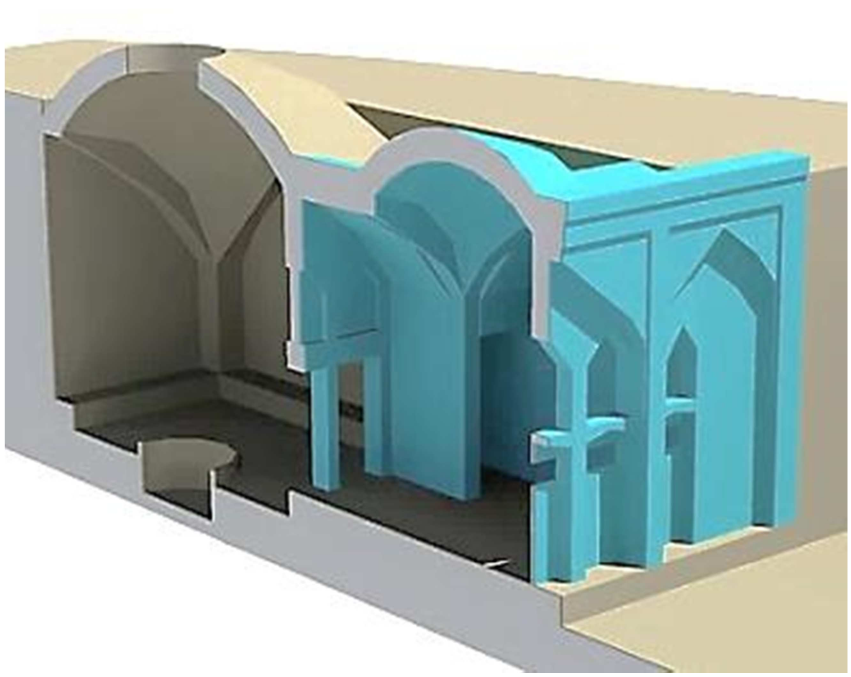

Figure 3-28: Computer modeling, case no.1. Created by author

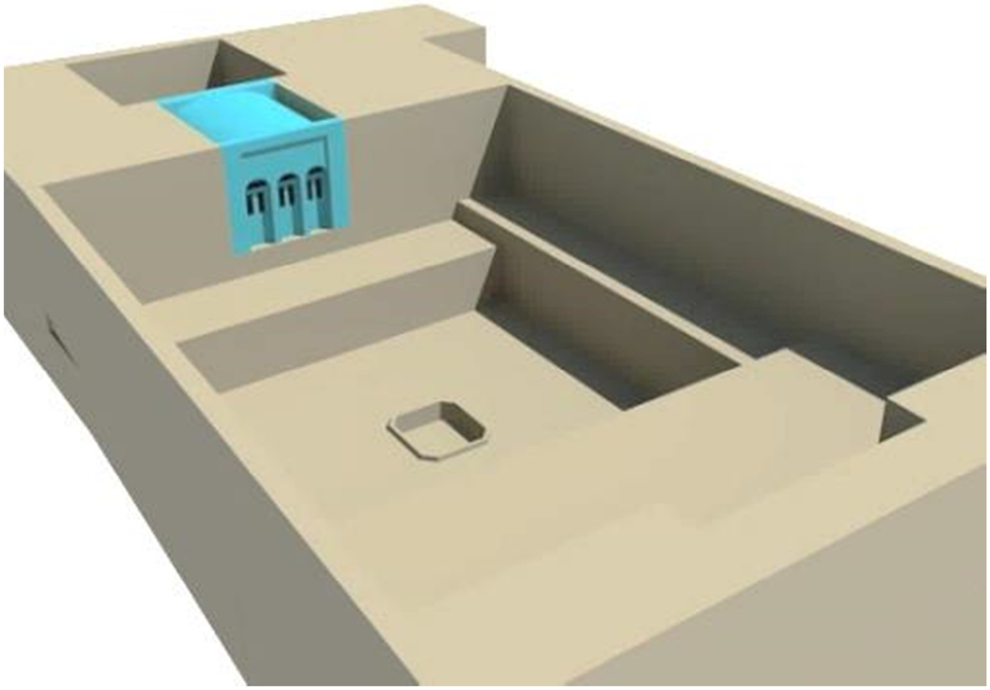

Figure 3-29: Computer modeling, case no.2. Created by author

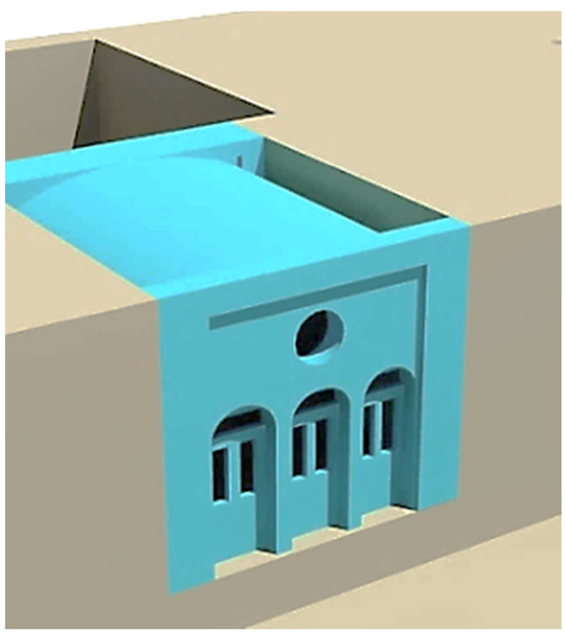

Figure 3-30: Computer modeling, case no.2. Created by author

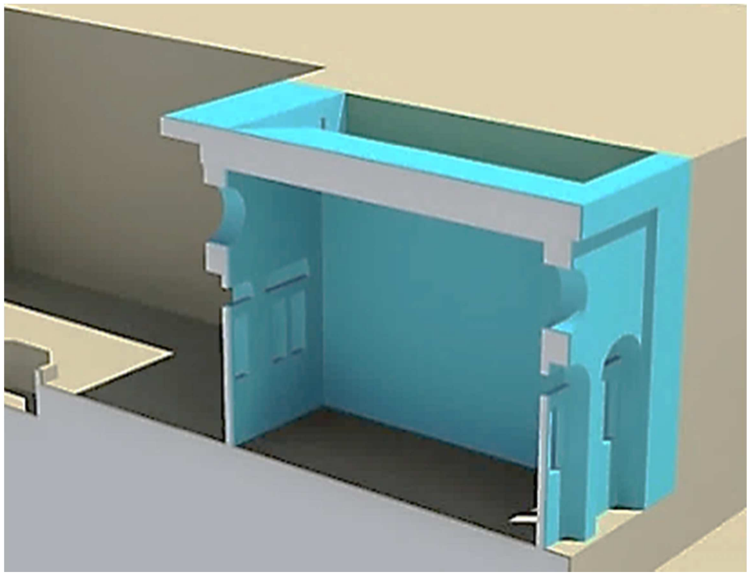

Figure 3-31: Computer modeling, case no.2. Created by author

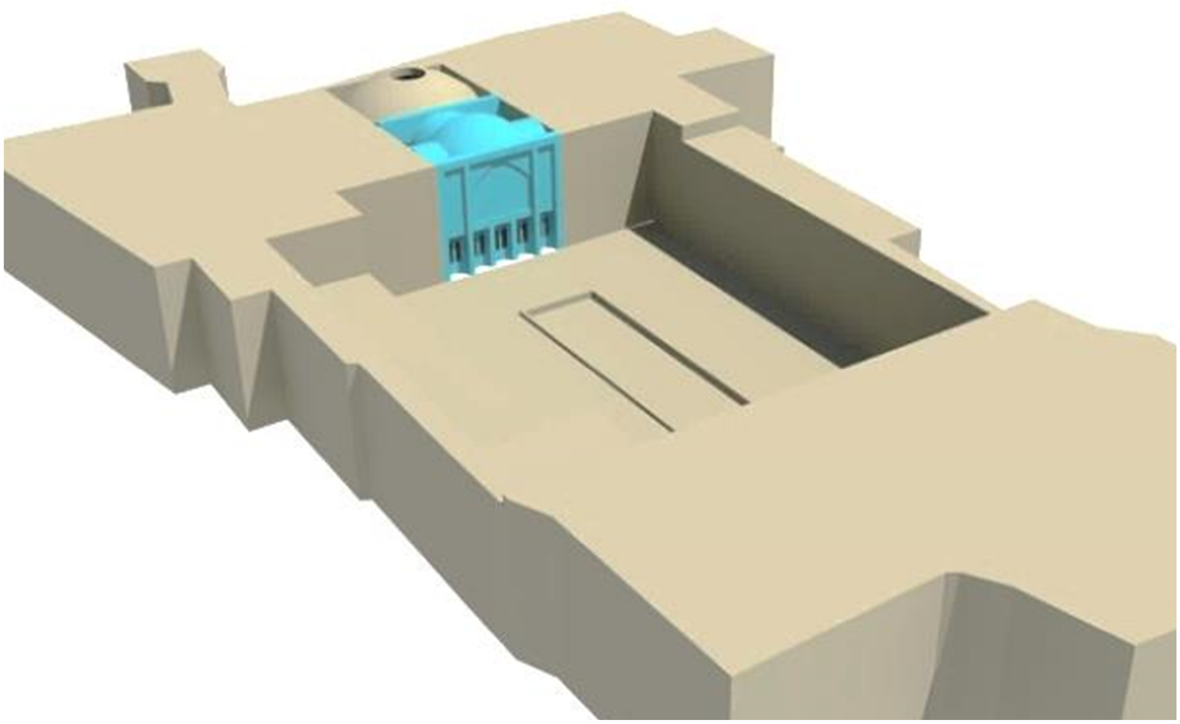

Figure 3-32: Computer modeling, case no.3. Created by author

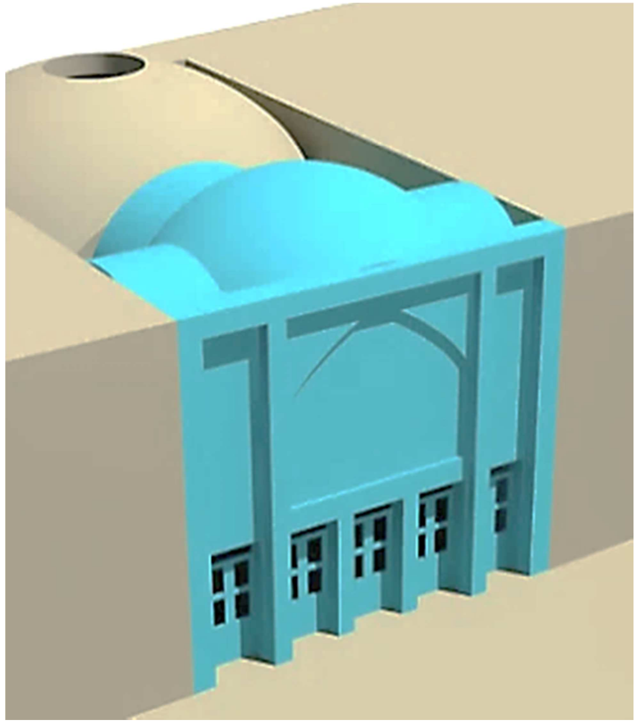

Figure 3-33: Computer modeling, case no.3. Created by author

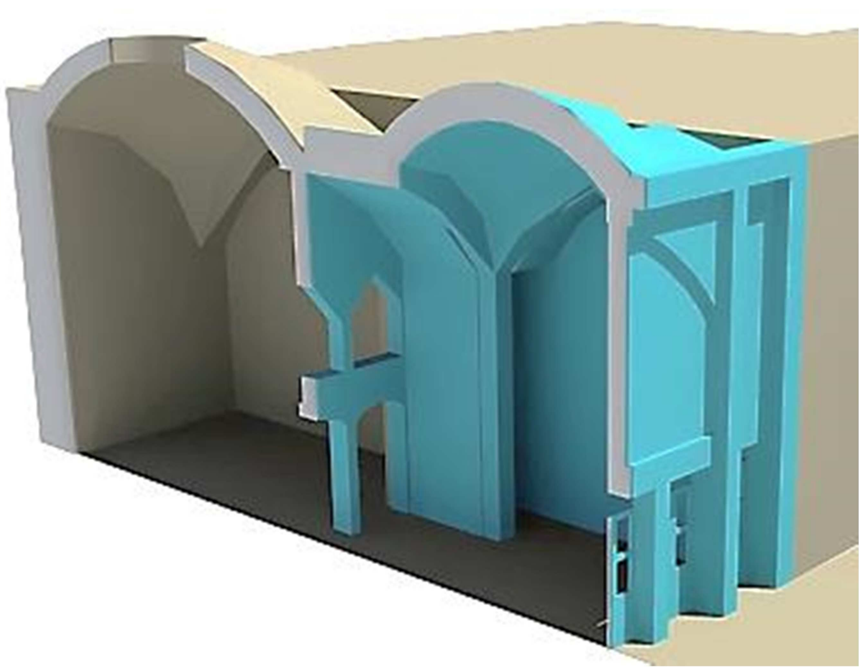

Figure 3-34: Computer modeling, case no.3. Created by author

The selection of the daylight simulation software used is due, in part, to the software's user-friendly interface, and its compatibility with modeling software (Autodesk® AutoCAD®) which is used in this research and furthermore the software's capacity to present accurate analysis in a relatively short time. A variety of simulation program were evaluated for use in this research. The first software was AGI32. This software was considered inaccessible mainly for its only focus on artificial lighting. The next software was Relux, suitable for analyzing artificial lighting aspects. As it suffered from the lack of ability for the analysis of daylight, it has ignored for applying in this study with the priority of daylight. Then, DAYSIM was evaluated to compute and analyze daylight level but it was unable to read models because of their complexity.

Finally Autodesk® Ecotect® was evaluated for daylight simulation in the models. This software presented accurate calculation results in a relatively short time. Therefore, this software was selected as the best chose for doing daylight simulation through this research. As stated by Autodesk Ecotect website (www.usa.autodesk.com/ecotect-analysis), this software visualizes incident solar radiation on windows and surfaces, over any period; calculates daylight factors and illuminance levels at any point in the model; and displays the sun's position and path relative to the model at any date, time, and location. Autodesk Ecotect was able to import the computer models with some modifications, and also to produce detailed daylight analyses and visual displays for comparison and study.

After selecting the daylight simulation software, the models were imported to Autodesk Ecotect to conduct required analysis (see Figure 3-35). Appropriate materials were attributed to models' components such as doors, walls, roofs and so on. For instance, by using Autodesk Ecotect, in each model, it was determined which window is single glazing and which is double (see Figure 3-36). After importing the models and the attribution of materials to their components for doing daylight analysis an analysis grid was defined inside the each model (see Figure 3-37 and Figure 3-38).

For analyzing daylight in the plan, regarding this fact that the daily tasks mainly were done on the floor in the traditional houses, the analysis grid was defined on the ground in all cases. Similarly, considering the symmetry and uniformity of the space geometry, for analyzing daylight in vertical state the analysis grid was situated in center of the room, (see Figure 3-39 and Figure 3-40). In fact, the distribution of the daylight is the same in all parts of the room in the vertical state because of this symmetric geometry. Therefore, the analysis of daylight was done for the three cases vertically and horizontally.

3.4.1. Daylight Simulation Process

For completing analysis and finding a better understanding on the distribution of daylight and also for understanding how openings function (regarding that the openings were located on two faces in each model), firstly, the openings on one side (adjacent to the backyard) were blocked and the others on the other face (adjacent to the courtyard) were kept open. And then, converse process was done. Furthermore, daylight analyses were done based on illuminance. Illuminance is a photometric term that quantifies light incident on a surface or a plane. It is commonly called light level. It is expressed as lumen per square foot (footcandles), or lumen per square meter (lux). this selection was mainly due to the available data of lighting standards for Iranian dwellings which were measured on Lux. Lux is the unit of illuminance in the International System of Units (SI) that refers to the intensity of light. One lux is equal to one lumen per square meter. One lux equals 0.093 footcandles. The following figures have shown the conducted analyses which were done through Autodesk Ecotect.

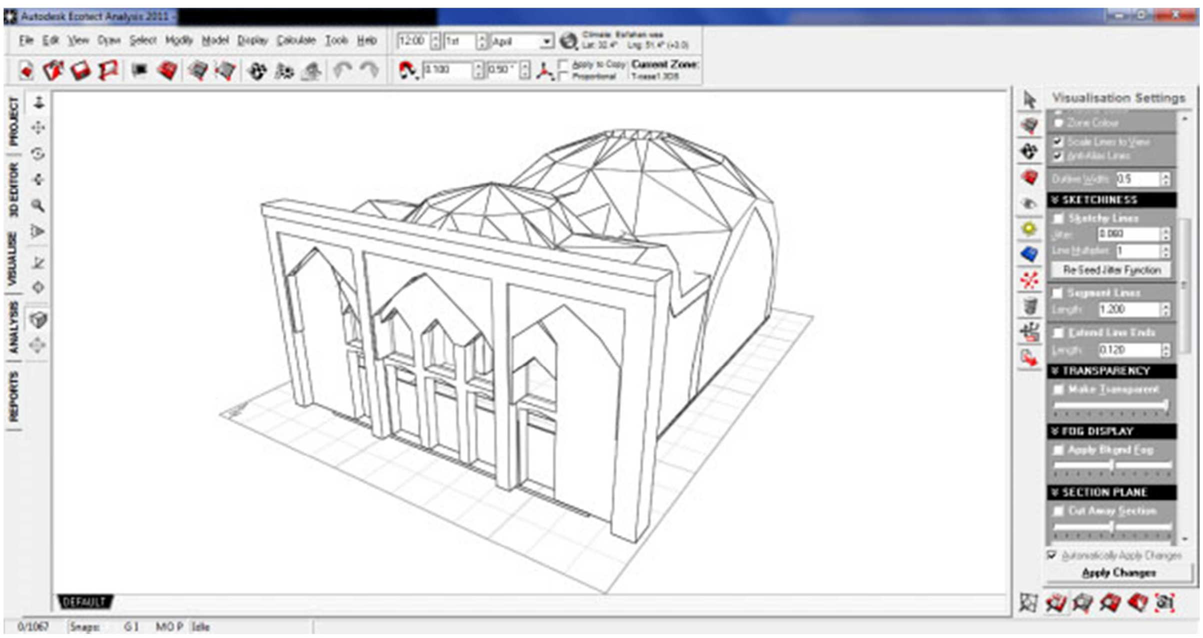

Figure 3-35: Computer daylight simulation, phase 1: importing models from AutoCAD into Ecotect. Created by author

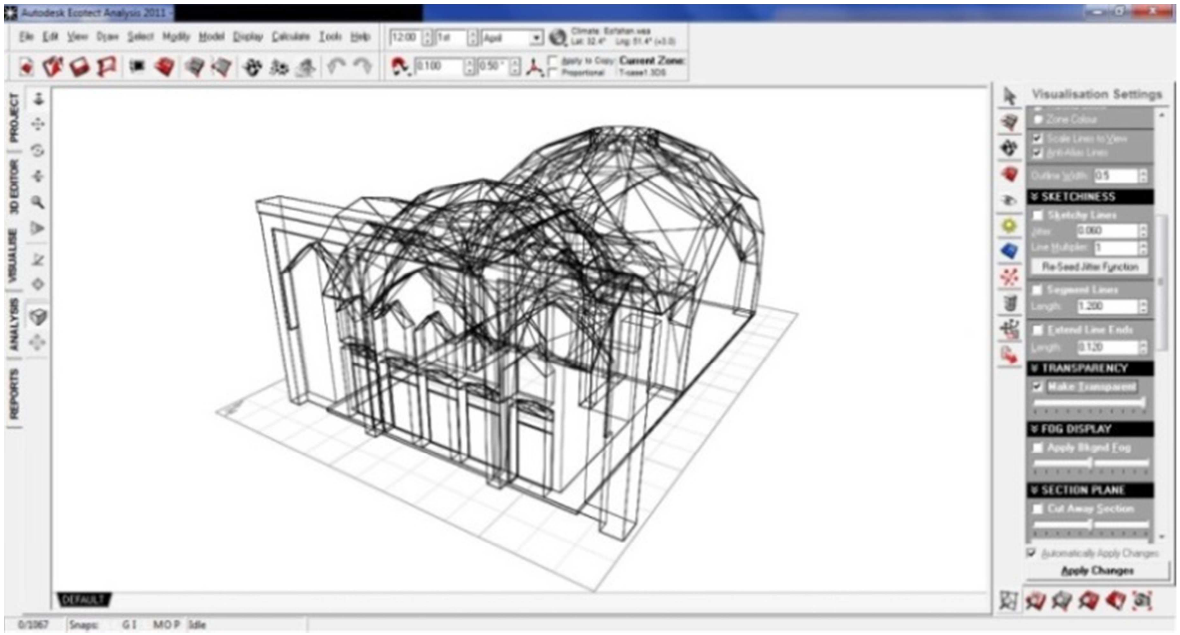

Figure 3-36: Computer daylight simulation, phase 2: distributing material to models components. Created by author

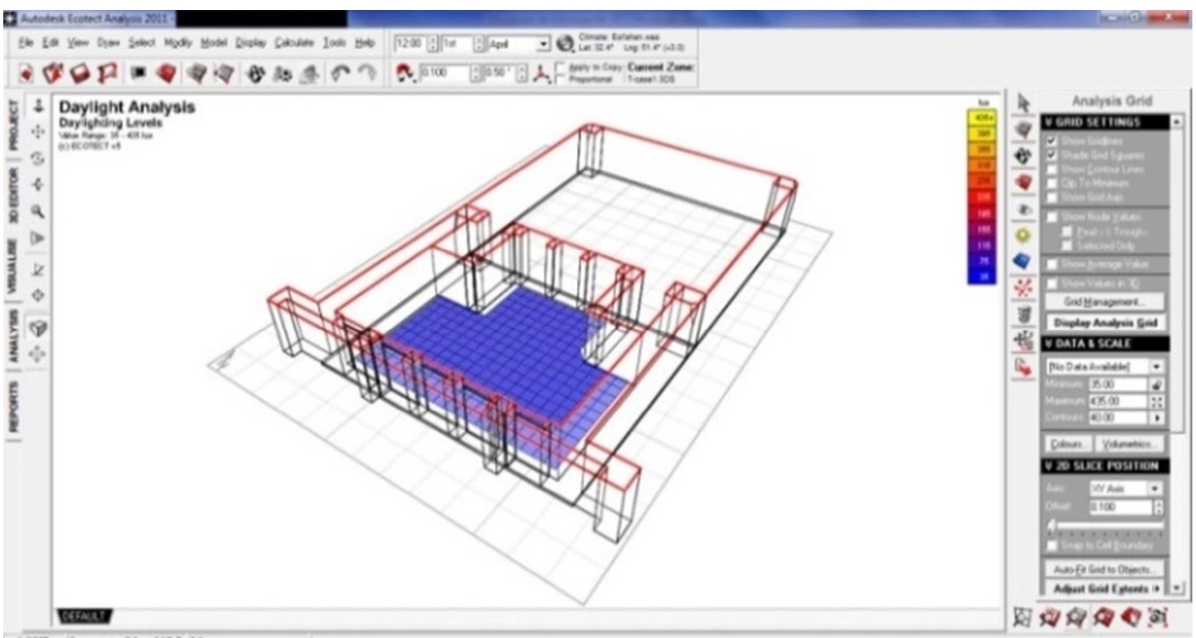

Figure 3-37: Computer daylight simulation, phase 3: defining horizontal daylight analysis grid. Created by author

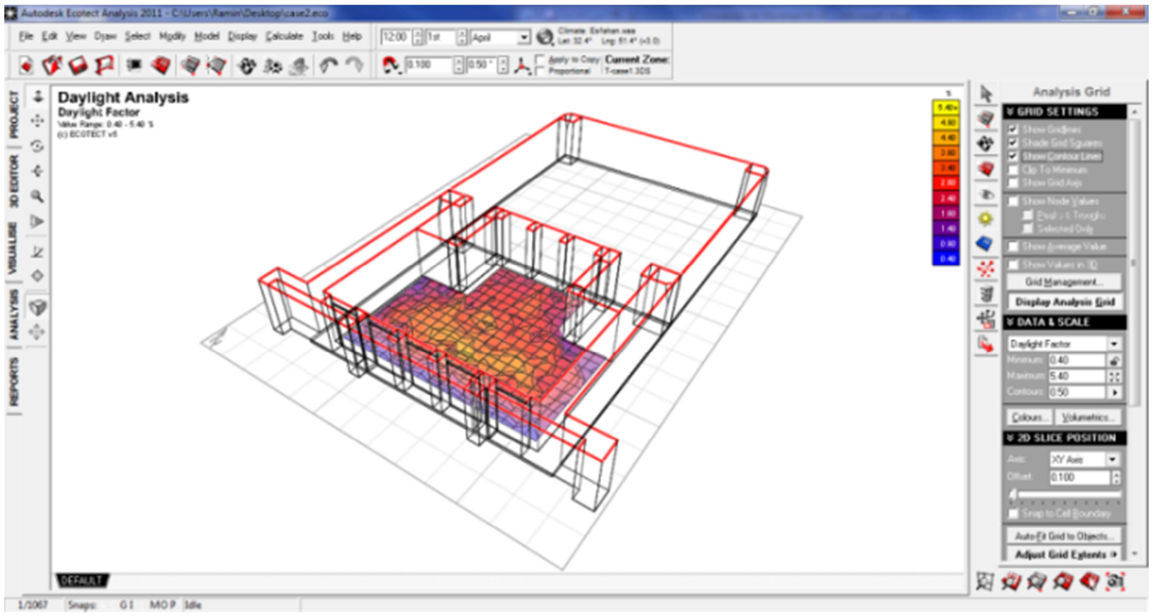

Figure 3-38: Computer daylight simulation, phase 4: analyzing daylight in plan. Created by author

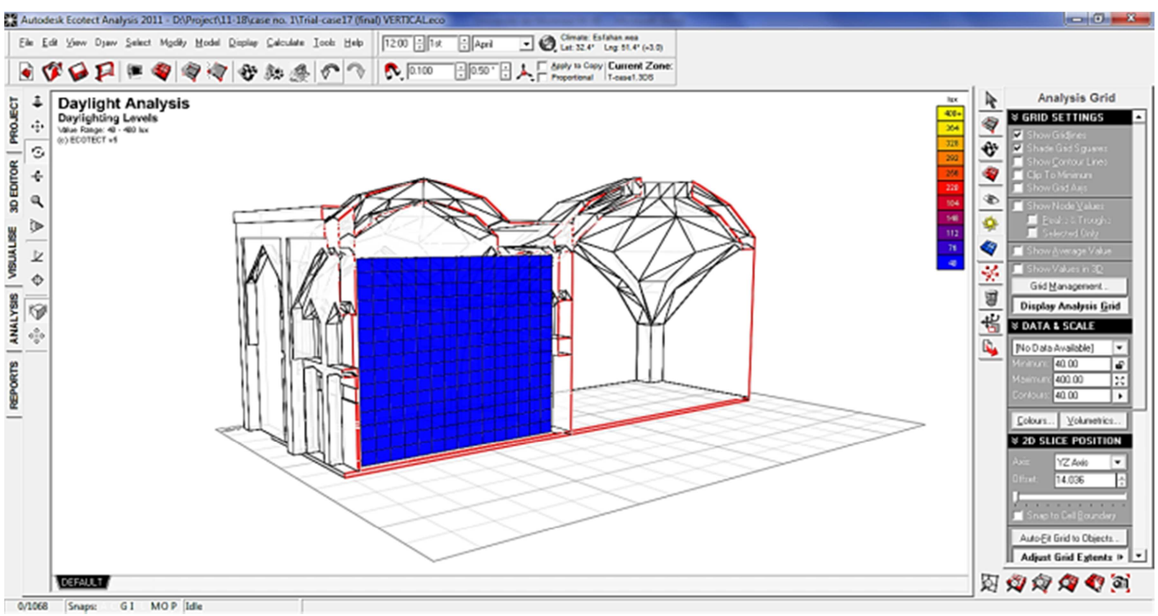

Figure 3-39: Computer daylight simulation, phase 5: defining vertical daylight analysis grid. Created by author

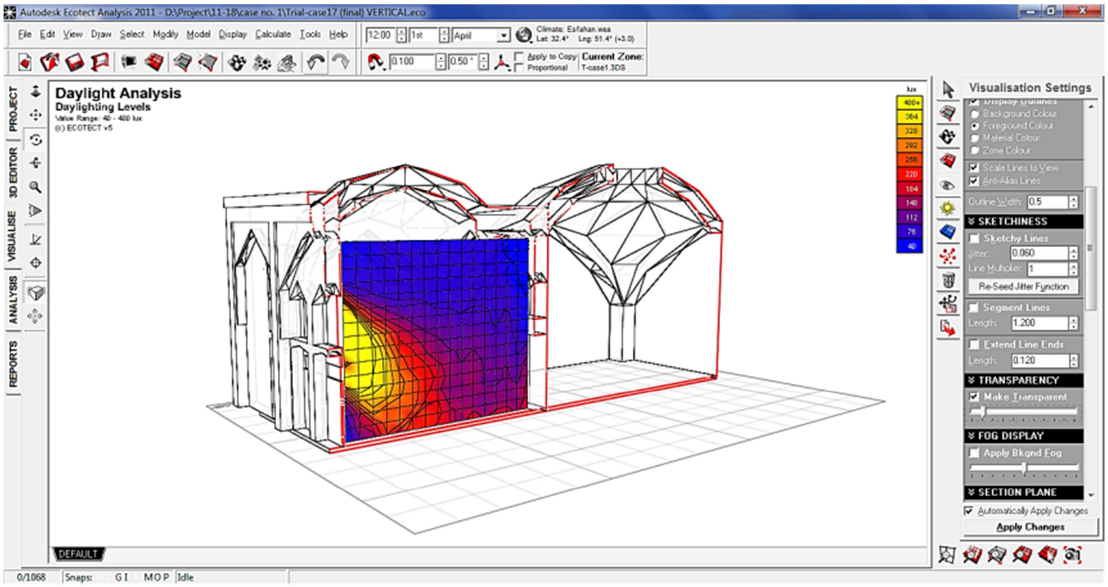

Figure 3-40: Computer daylight simulation, phase 6: analyzing the daylight in section. Created by author

CHAPTER 4

4. Presentation and Analysis of Results

4.1. Questionnaire Analysis

As noted in the previous chapter, the questionnaire consisted of 3 parts: 1) in the first part: “personal experiences”, the participants were asked about the importance of daylight in design process of residential buildings. 2) In the second part: “current situation of dwelling”, the participants were questioned about the current problems in Iranian dwellings in terms of using daylight; also, about potential ways out. 3) Finally, in the third part: “traditional residential buildings”, participants were asked about the significance of daylight in Iranian traditional residential buildings, how these houses achieve in benefitting from daylight and the possibility of extrapolating these achievements as possible solutions into current Iranian residential dwellings.

The analysis of the questionnaire responses was done in three steps: firstly, the answers to each question given by the participants were gathered and compared separately. Secondly, noticeable issues mentioned by the participants in each part of the questionnaire were identified, and the shared issues were highlighted as the salient points. Indeed, this analysis method has helped to identify the salient elements that were mentioned mutually by the participants. In addition, this analysis method has increased the importance and the validity of each salient element through understanding the frequency of the shared points.

4.1.1. Emerging Issues

First Part: Personal Experiences

As already mentioned, the principal subject of the survey's first part has focused on the importance of daylight in the design process of residential buildings in Iran. In this part the participants were questioned about: the importance of daylight in the design of Iranian dwellings, its order of priority; and finally positive and negative points of using daylight in residential projects. Daylight was considered by all of the participants, without exception, as a principal and important factor in the design process of the residential buildings in Iran. The participants each had various reasons for considering daylight as an important factor; some believe that the use of daylight improves the quality of spaces significantly and others have indicated how daylight impacts on people and their performance in spaces. Furthermore, some participants have mentioned that using daylight in residential buildings provides both lighting and also a view to outdoor and a bridge between inside with the outside world.

Issues such as building orientation, the layout and the proportions of the spaces which are interacted with the location and size of windows were mentioned as issues by the participants. They have stated that the proper building orientation has a great impact on effectiveness in different daylight zones of buildings. These zones are located in the different sides of the building based on their required daylight. Applying such an orientation optimizes the beneficial use of daylight in buildings. In addition, the participants have indicated that this orientation effects on the layout of spaces in buildings. Therefore, spaces with a high priority in using daylight are located in zones with more accessibility to daylight and vice versa. Simultaneously, windows and openings were mentioned as effective elements by the participants as well as the influences of location and their size on the amount of illumination that spaces received.

In addition, the participants have stated mostly a similar order of priority for using daylight in the spaces of Iranian dwellings. According to participants, in the spaces such as the living room and bedrooms, daylight is a fundamental requirement, while for the kitchen it is considered as an afterthought, and in bathrooms daylight is considered a low priority. Other factors that emerged include how daylight is affected by the particular climate of a region or the special pattern of users' daylong activities in a space.

As a strength point in their projects, the participants stated that following a daylight-based approach in residential design decreased obviously the use of artificial lighting and consequently reduced the consumption of electrical energy as well as the negative impacts of artificial lights on well-being. Furthermore, as another minor advantage, windows and openings provide a bright view into spaces from the outside, and function as an imaginary bridge to connect the indoor to outdoor world, acting as a frame for capturing the nature beauty. Besides, there are some other side effects accompany the main benefits which were mentioned that have great impacts on participants physically and physiologically including user's performance and user's health. For instance, using daylight in spaces and providing a view from outside significantly reduced the depression.

On the other hand, the participants have mentioned that using daylight in most cases have necessitated accepting an order of priority in design. This order of priority is mainly because of limited day-lit zones in a building. Indeed, spaces with high priority over using daylight are located in day-lit zone and the rest of spaces are left compulsory in other areas. In similar cases, by way of compensation for daylight, a vertical void is used in residential buildings (most frequent in residential apartments). The participants have claimed, using such vertical voids for using daylight in residential buildings reduces significantly the quality of spaces adjacent to the void and dedicates a large part of buildings' area to it.

Second Part: Current Situation of Iranian Residential Dwellings

The second part of the survey has focused on participants' viewpoints about the current situation of residential buildings in Iran in terms of benefiting from daylight. The participants were asked about issues such as: the limitations of using daylight in an Iranian dwelling and possible alternatives.

A principal issue which were discussed by almost all participants is privacy, a cultural-religious issue, or as some participants called it: "neighbours view" or "view from outside to inside". Privacy is mentioned as a factor which controls the visual-audio interaction between houses inside and outside, however privacy should not lead to isolation. The participants have believed that privacy as an inherent feature of Iranian religion and culture (according to the ancient Iranian believes and thereafter due to the emphasis of the Islam on privacy between inside and outside, man and woman, host and guest and etc.) is a key point in the design process of Iranian dwellings. In following, the participants have mentioned that occupants in order to provide required privacy in their houses, either cover windows by thick curtains or in some cases prefer using daylight through voids instead of providing daylight from public open areas.

A second issue that some participants have stated is that some of the current municipal legislation has caused difficulties in terms of using daylight in dwellings. The participants have stated that the city hall has set legislations which limit designer to access daylight as they will. For instance, new building legislations allow buildings to cover 60% of land parcel and to leave 40% for open spaces. Considering that land parcels are mostly in narrow rectangular form and the building can be located in the northern or southern part of the land, the houses access to daylight only from one side.

Furthermore, in parcels which building is situated in the northern part of land, the city hall obliges considering a vertical void in the northern side of building. This void aims to limit the view of residents into neighbouring areas and to provide neighbours with more privacy. This issue in most cases causes the reduction of daylight in spaces and significantly decreases the quality of lighting in these spaces. The participants have also mentioned that the lack of legislations for controlling building's height leads to the construction of higher buildings in neighbouring areas which blocks the penetration of enough daylight into lower residential levels in a building.

Finally some participants have pointed to a build-and-sell approach in housing construction as another issue where profit is of more value than housing itself. These participants have mentioned about locating more bedrooms in a residential unit (for example, 3 bedrooms instead of 2) to increase the final profit results in bedrooms; extra rooms are lit indirectly from other spaces.

Regarding privacy in residential buildings, the participants have proposed mostly strategies for providing privacy in dwellings including the correction of population distribution, increasing distance between buildings and the study of daylight techniques which were used in traditional residential architecture of Iran to provide required privacy; however some participants have believed that the current problems concerning privacy is solvable through public cultural-based educations via media.

About municipal legislation, all the participants have suggested reviewing and modifying the municipal legislations with regard to the existing problems of reconciling privacy with user needs. The participants have also mentioned the necessity of preventing the construction of residential buildings by non-qualified persons or according to their taste, issues seen as affecting overall building quality. A participant has suggested that convincing clients by showing well-constructed residential samples or sharing information between clients and the residents of these well-constructed buildings is useful.

Third Part: Traditional Residential Buildings

This part has focused mostly on the participants' knowledge concerning Iranian historic dwellings (particularly Iranian traditional courtyards) and their success in benefiting from daylight. Finally, the participants were questioned about the possibility of extrapolating traditional methods of using daylight into modern houses in order to optimize the use of daylight. Finally, they were asked to introduce some examples of contemporary dwellings in which the use of daylight were optimized be regarding the traditional methods of using daylight in courtyard houses.

All participants have stated that they have had an average or acceptable level of knowledge about Iranian historic residential architecture. Almost all the participants, without exception, have answered that Iranian historic residential architecture was presented a successful example in terms of benefiting from daylight. A participant, by accepting this success, has mentioned: "… the traditional residential architecture, throughout numerous years and in successive generations, via examining various methods had achieved a high efficiency in benefiting from daylight." Some participants, by comparing Iranian traditional houses with contemporary examples, have claimed that traditional houses were more successful in terms of benefiting from daylight. They have claimed mostly that the success of traditional dwellings in the field of using daylight is mainly due to some important features that were used in the structure of these houses such as the orientation of these houses which follows optimizing the penetration of daylight into spaces, the layout and proportions of spaces which were based on a pattern to maximize the use of daylight and finally the dimension and location of windows and opening which have controlled the rate of daylight arriving within spaces.

The participants have suggested that the pattern of using daylight in traditional houses can be proposed as a solution for current problems despite the neglect of the potential use of daylight as a primary source. However, they also have stated that extrapolating traditional techniques of using daylight into contemporary dwellings necessitates finding a comprehensive understanding about these techniques and then updating and adapting them to the modern houses and to lifestyle through using new building technologies.

On the other hand, some participants have believed that it is not possible to benefit from traditional techniques of using daylight in contemporary era. One participant suggests that the new lifestyle is a main reason. He states: "… as there are many differences between lifestyle in traditional houses comparing to contemporary ones, judging about the possibility extrapolating historic technique of using daylight into modern dwellings is really difficult.” In this group, another participant believes that traditional daylight techniques solely cannot be used and says: “If all aspects of Iranian traditional houses are not considered in a design, using traditional techniques of using daylight solely is like a patch on the building.” Another reason that they have given is that: “… a dominant part of the modern industry of housing construction uses a modern typology which left no room for using traditional methods of using daylight.”

In the last part, the participants mostly have responded with a big “NO” or they have not mentioned to any special building directly when they were asked to give an example of a contemporary house in which the use of daylight were optimized through regarding traditional technique of using daylight. However, some participants have indicated that there are examples of this claim, but those are only a formal copy.

ANALYSIS OF THE QUESTIONNAIRES (with 8 participants)			
SECTION	FIRST PART	SECOND PART	THIRD PART
TOPIC	Personal Experiences	Current Situation of Dwelling	Traditional Residential Buildings
SALIENT ELEMENTS	–daylight as an important element –building orientation –space layout –space proportion –windows location and size –views –energy savings –consumption reduce	–privacy –legislative norms on building –"build and sell" issues	–success –unique structural features –update current using ideas of traditional architecture –issue of lifestyle affecting its usefulness

Table 4-1: Salient elements of questionnaire. Drawn by author

4.2. Analysis of Daylight Simulation

The results of computer daylight simulation were evaluated for each case and then compared to each other for this analysis phase. The results were taken from several factors, including model structure and computed Autodesk Ecotect data. The extracted results of daylight analysis were mostly similar in all 3 cases; however their interior illuminance diagrams were differences, depending on their features. The Ecotect data below shows illumination levels for each case and these were measured in lux. They have represented the amount of daylight inside the cases. They have represented illumination levels in the worst-case design scenario based on an overcast sky distribution in mid-winter (Kensek & Suk, 2011; Vangimalla, Olbina, Issa, & Hinze, 2011). Then, these amounts were compared with the Iranian lighting standards for residential buildings (see Table 4-2).

Residential Places		
Place	**Minimum illumination Lux**	**Suggested illumination Lux**
Sitting and living room	70	200
Studying room (writing and reading book and newspaper)	150	500
Kitchen (sink' oven and work table)	100	200
Bedroom: – General lighting – Lighting bed and makeup table	 50 200	 100 500
Bath room: – General lighting – Mirror (for shaving)	 50 200	 100 500
Stairs	100	150
Aisle, halls and elevator	50	150

Table 4-2: Lighting standards of residential buildings in Iran . Topic No. 13 of the national buildings codes in Iran, and Standard No. 1937 of the institution of standards and research of Iran. Translated and created by author

4.2.1. Emerging Issues

Case No. 1

The diagram in Figure 4-4 has represented the amount of illumination measured in lux5 for the case no. 1. There is an abundance of daylight within the space which has attributed to the 38 square meter area of the room. As Figure 4-4 has shown, the average illumination levels in the room is around 200-250 lux which is in accordance with to the suggested Iranian standards for the lighting of living rooms in residential buildings (200 lux) (see Table 4-2). Furthermore, based on the lighting standards of Iran, there barely has existed any point which has not received enough daylight (70 lux), even in the worst-case design conditions.

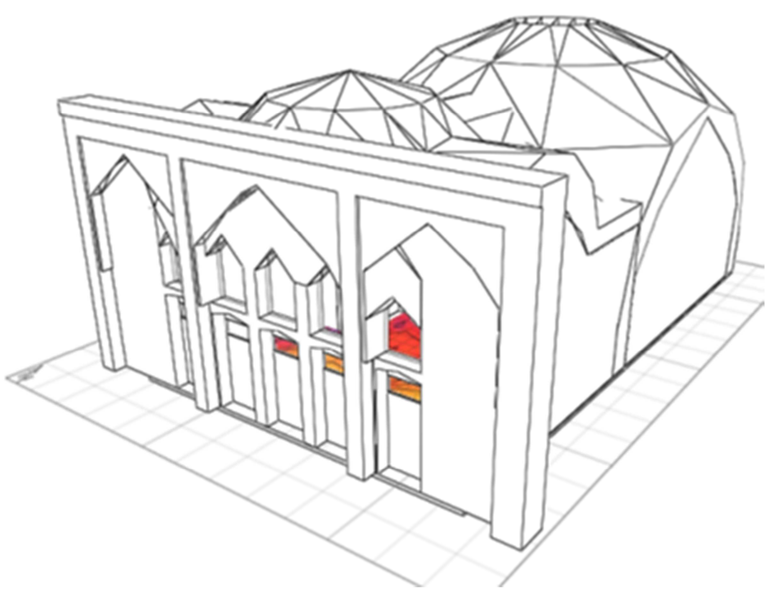

Figure 4-1: Case no. 1 presentation. Created by author

[5] Lux is the unit of illuminance in the International System of Units (SI) that refers to the intensity of light. One lux is equal to one lumen per square meter. One lux equals 0.093 footcandles.

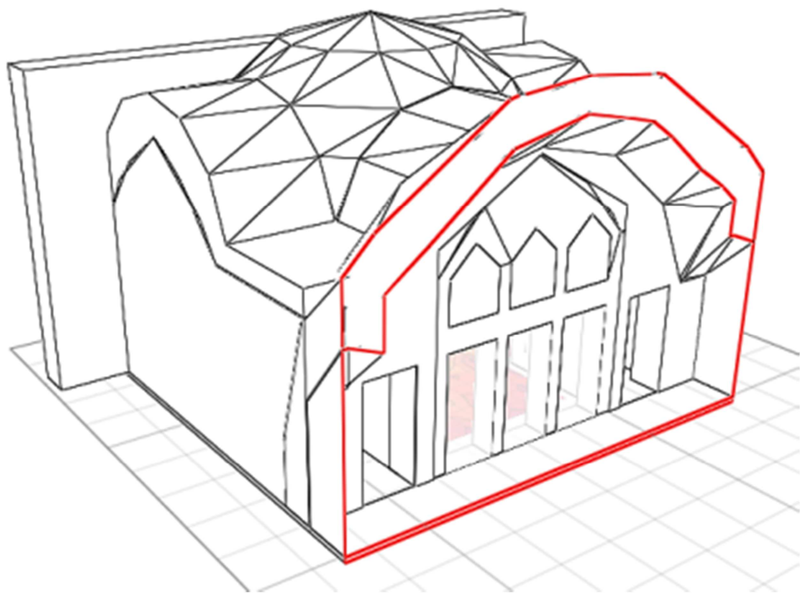

Figure 4-2: Case no. 1 presentation. Created by author

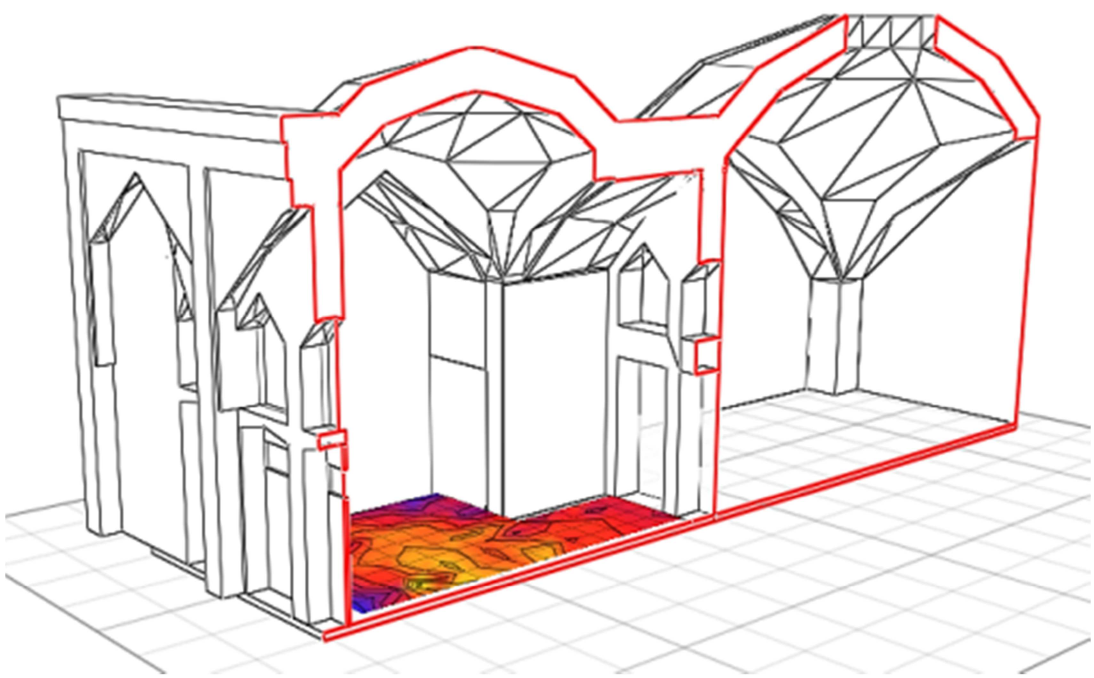

Figure 4-3: Case no. 1 presentation. Created by author

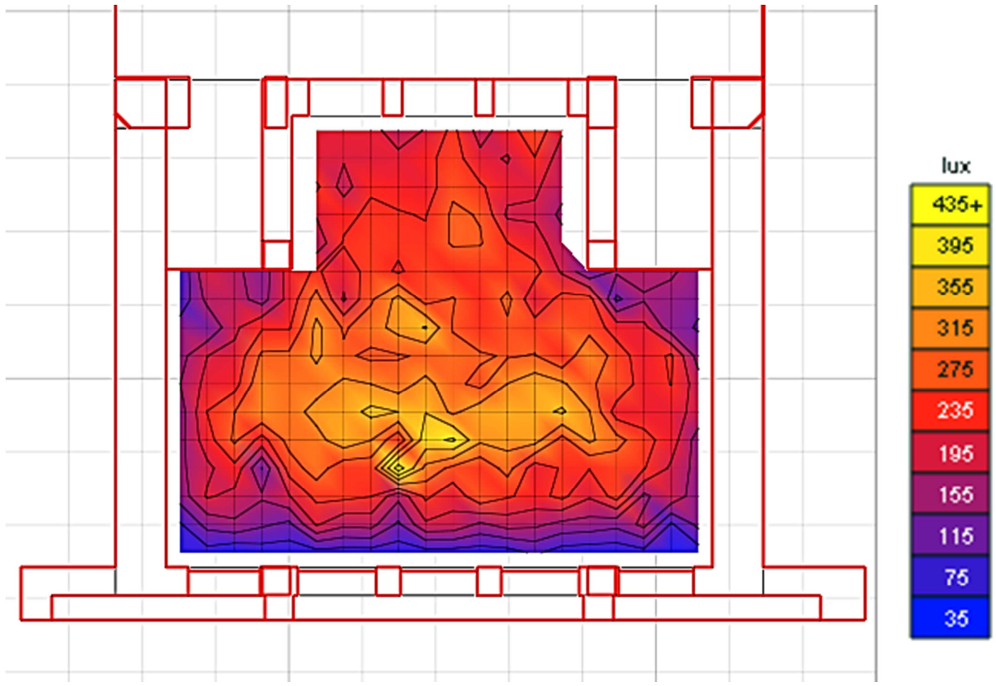

Figure 4-4: Horizontal daylight level analysis, case no. 1. Created by author

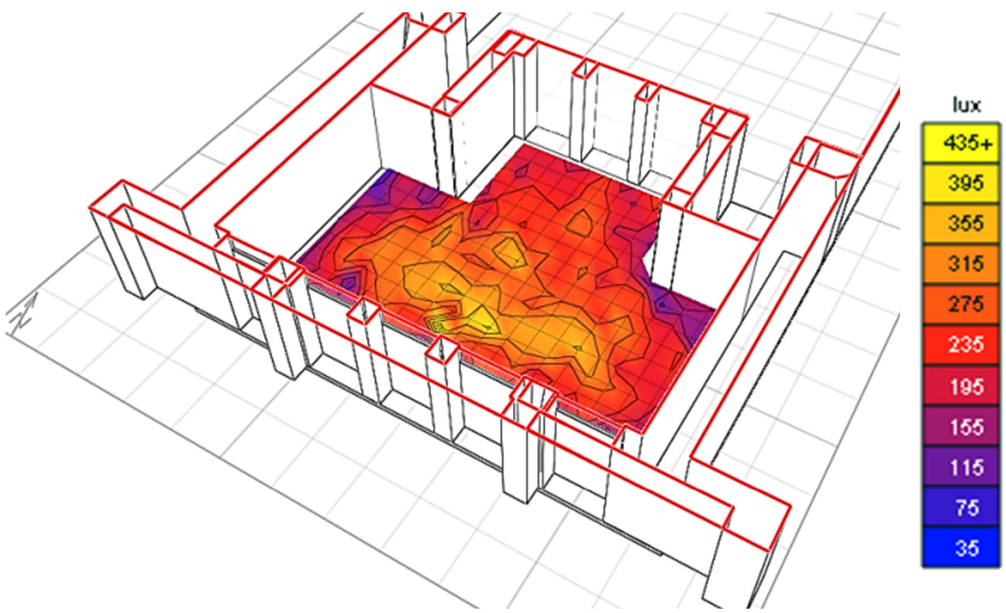

Figure 4-5: Horizontal daylight level analysis, case no. 1. Created by author

In this case, the general southern-northern orientation[6] of winter living rooms has had a westward rotation (approximately20 degrees). Considering winter days are shorter, with fewest hours of daylight, this 20 degree westward rotation has caused to benefit from daylight until the last minutes of day in the winter. Daylight mainly has penetrated into the room throughout five large single glazing windows in the upper side of the southern wall (courtyard façade) and five smaller windows which have aligned under them (on the top of the doors). While, in the northern side (backyard elevation), there were only three wooden lattice apertures on the lower side of the wall which brought the required amount of daylight into its small adjacent areas. In Figure 4-6 the penetration of daylight in the case no. 1 was analyzed in a hypothetical situation when its openings on one side were completely closed.

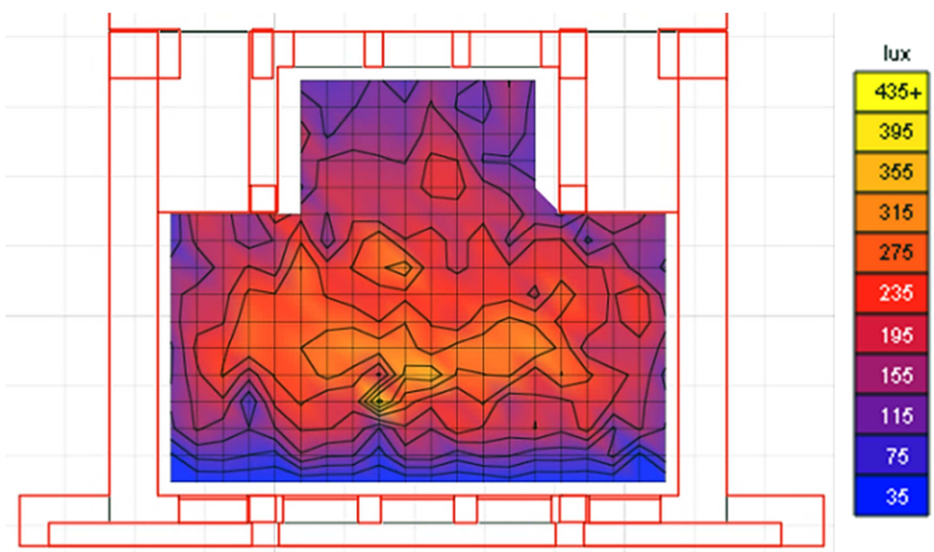

Figure 4-6: Hypothetical daylight level analysis, case no 1, northern windows close. Created by author

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[6] A southern-northern orientation was applied in winter living rooms in order to maximise the use of daylight during the winter days.

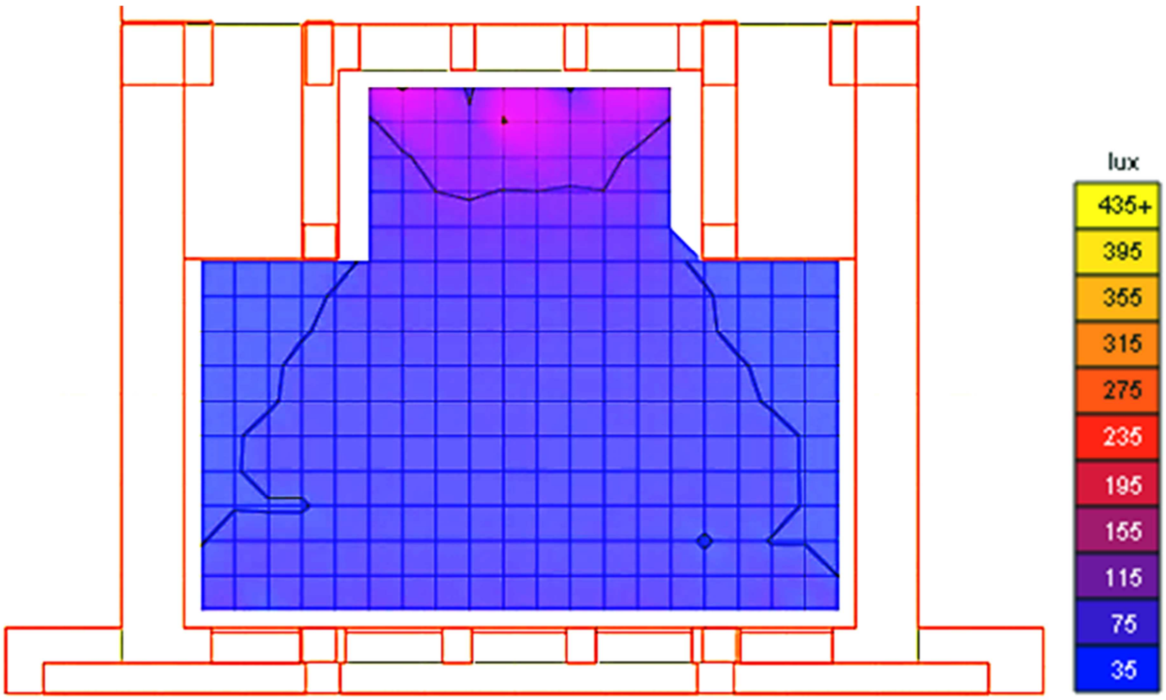


Figure 4-7: Hypothetical daylight level analysis, case no 1, southern windows were closed. Created by author

Hence, as data analysis has represented, in the case no. 1, daylight mainly has provided through the openings of the southern side. Placing the large windows on the upper side of the wall has caused to create a large central lit-area within the space. Indeed, the main central space was well-lit throughout the day while only the side spaces becoming fairly dark and obscure. Thus, within the small adjoining parts, ample diffuse daylight was provided throughout the lattice windows along the bottom of the northern wall.

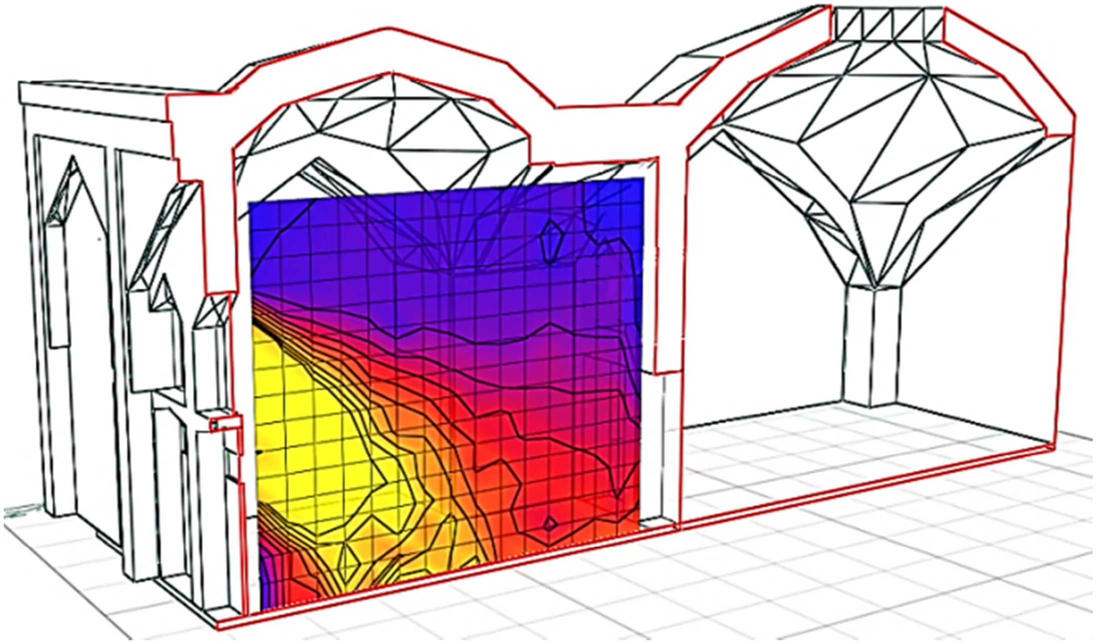


Figure 4-8: Vertical daylight level analysis, case no 1. Created by author

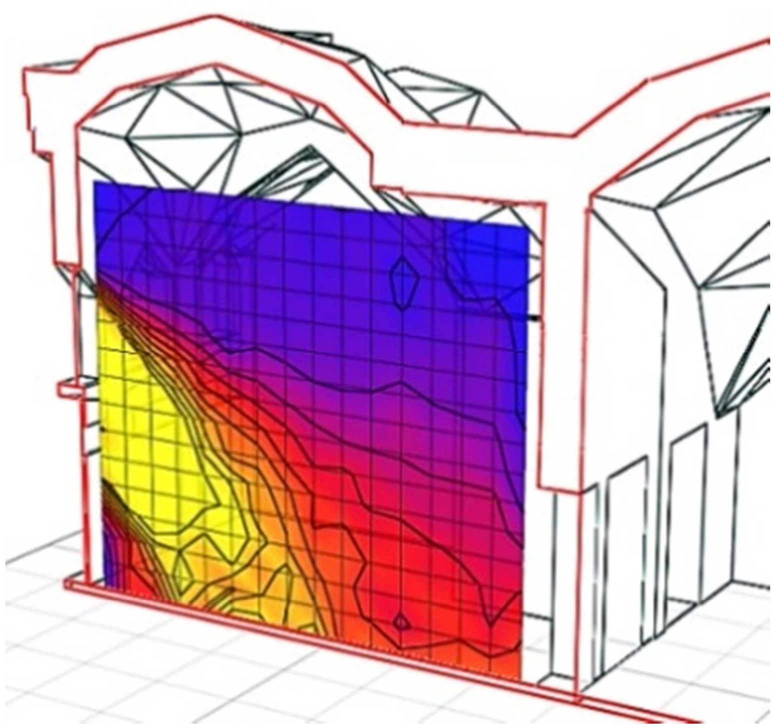


Figure 4-9: Vertical daylight level analysis, case no 1. Created by author

Case No. 2

The diagram in Figure 4-13 has represented the amount of illumination measured in lux for the case no. 2. The winter sunlight has provided illumination levels around 200-250 lux in the centre of the room. The illumination level average has decreased in the side spaces; however the minimum required daylight, 70 lux according to the standards of lighting in Iran, still was provided in the side spaces.

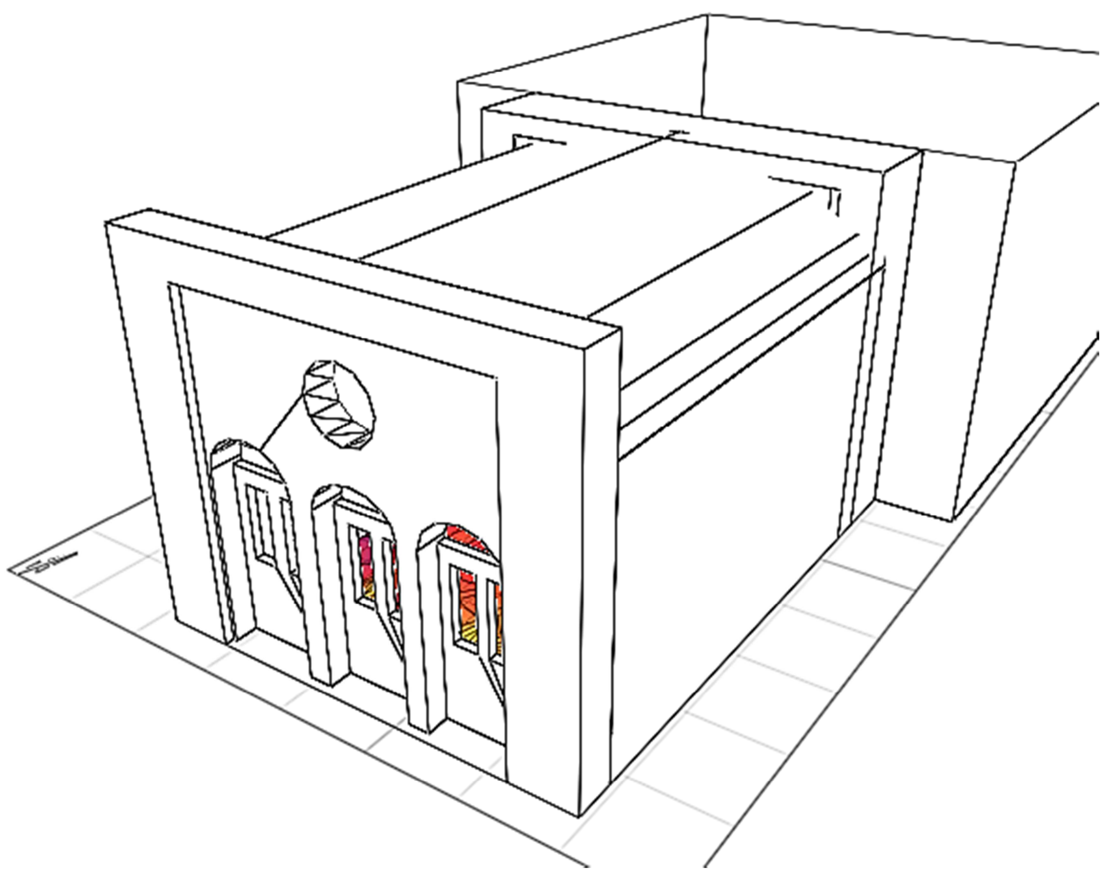


Figure 4-10: Case no. 2 presentation. Created by author

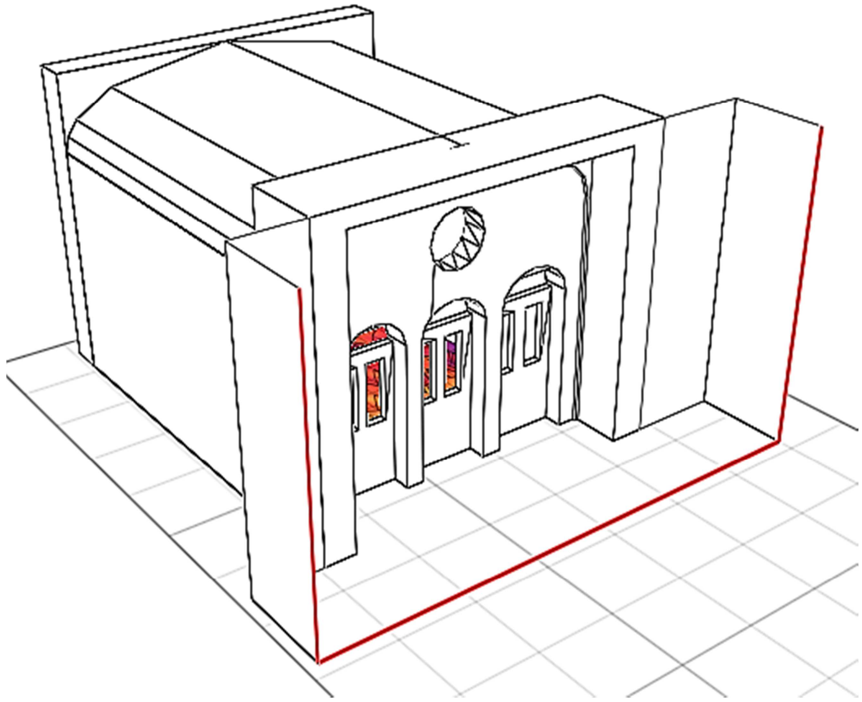


Figure 4-11: Case no. 2 presentation. Created by author

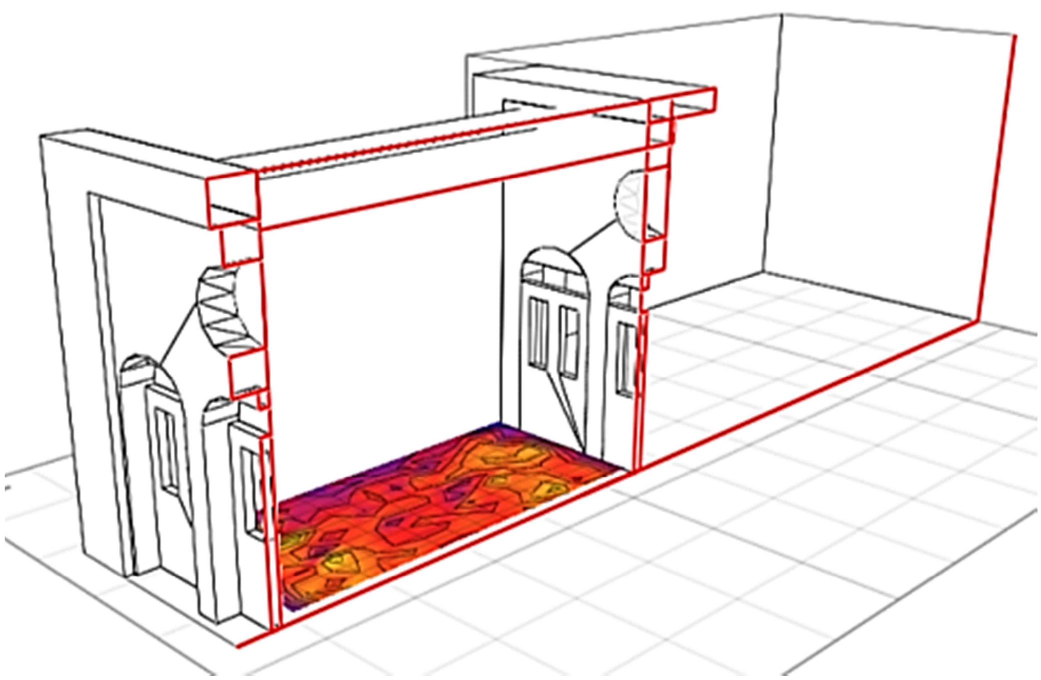


Figure 4-12: Case no. 2 presentation. Created by author

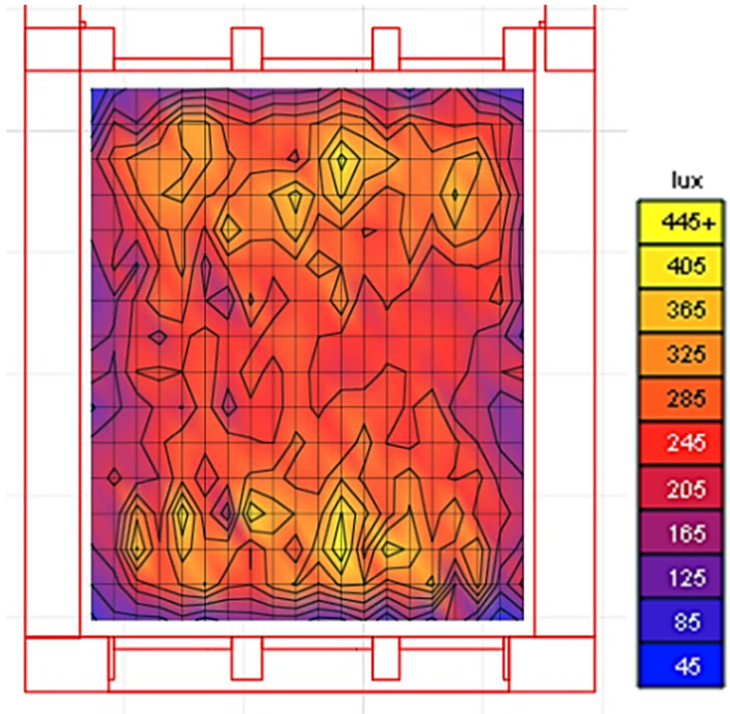


Figure 4-13: Horizontal daylight levels analysis, case no. 2. Created by author

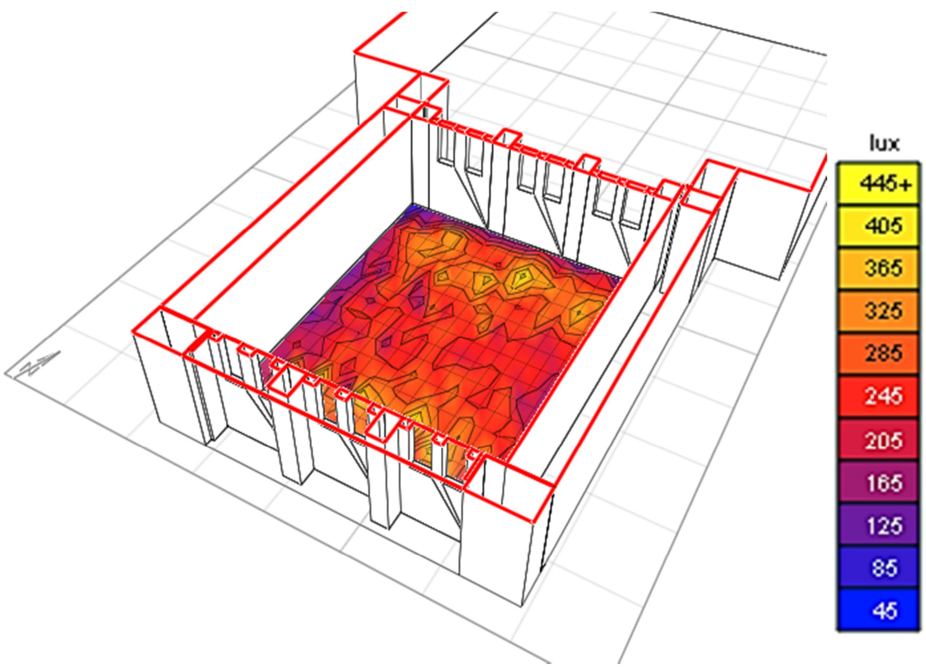


Figure 4-14: Horizontal daylight levels analysis, case no. 2. Created by author

The windows from two sides have cooperated to provide abundant daylight within the long interior space of the room. Therefore, the large south facing windows were used to bring the required daylight to the southern part of the space when the northern large windows have sought to capture needed daylight for the rest of the room. The principal windows were mostly on the lower portions of the southern and northern walls and they have captured the most available daylight. In Figure 4-15 the penetration of daylight in the case no. 2 was analyzed in a hypothetical situation when its openings on one side were completely closed.

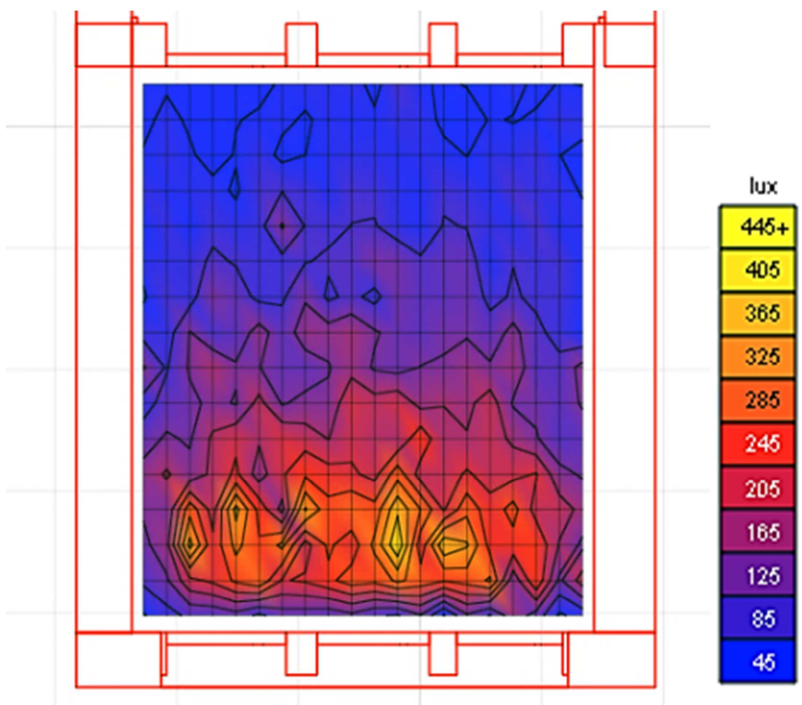


Figure 4-15: Hypothetical daylight levels analysis, case no 2, northern windows close were closed. Created by author

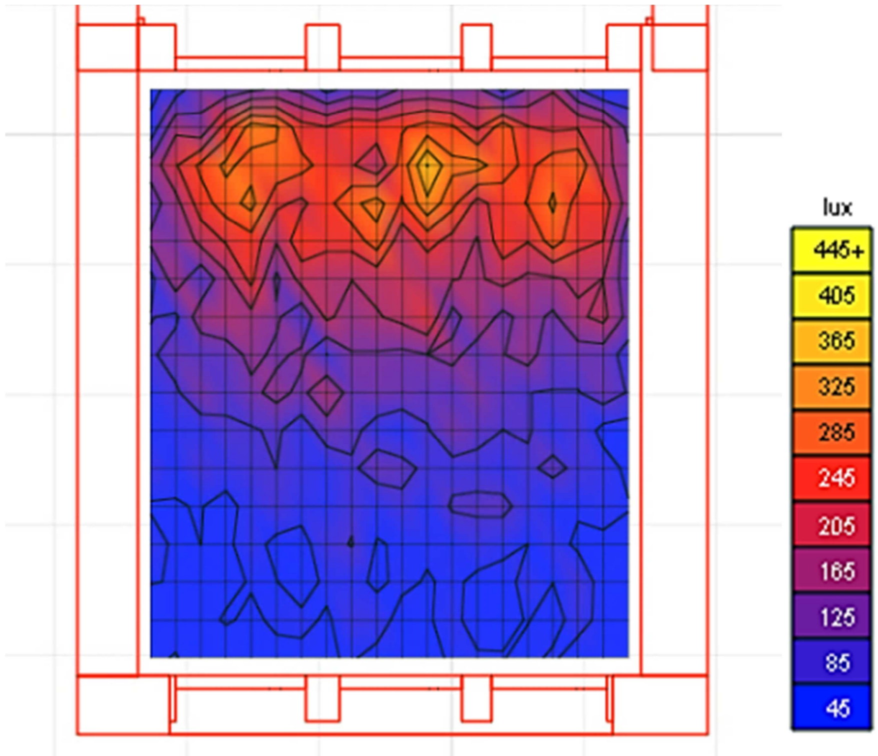


Figure 4-16: Hypothetical daylight levels analysis, case no 2, northern windows close (left) and southern windows close (right). Created by author

The required daylight within the room was provided mainly through the southern and northern large windows; however there also was a circular lattice aperture on the top of each wall. The two small circular lattice windows, located on the top side of the northern and southern walls, have brought diffused daylight into the darker upper side of the room and increased significantly the visibility in the adjacent areas. In this case, the dominant southern-northern orientation of the winter living room has followed an eastward rotation. Since, this rotation has limited the penetration of daylight during the evenings; it was probably influenced by other factor such as topography or etc.

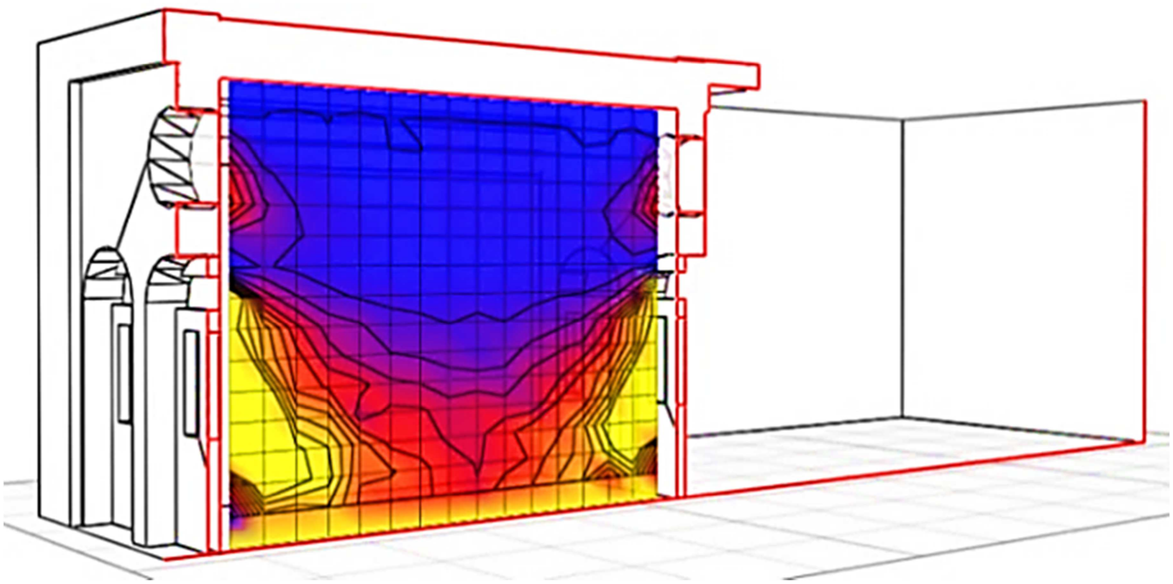


Figure 4-17: Vertical daylight level analysis, case no 2. Created by author

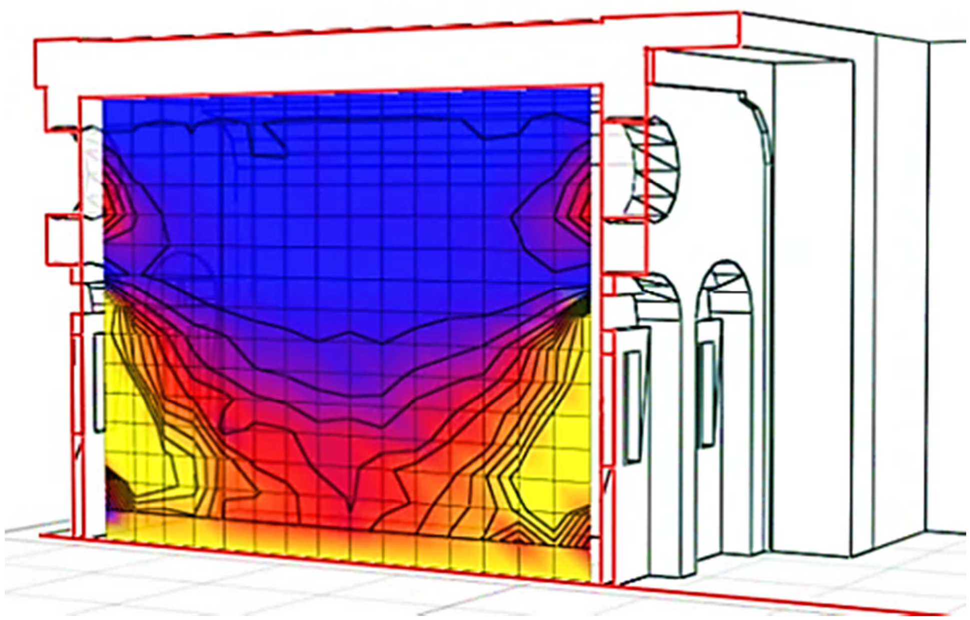


Figure 4-18: Vertical daylight level analysis, case no 2. Created by author

Case No. 3

The data in Figure 4-22 have revealed the illumination level in lux measured for the case no. 3. As Figure 4-22 has shown, the illumination levels in the room are around 200-250 lux and this is similar to the two other cases. This amount of daylight has responded to the required lighting standards of living rooms Iran which is 200 lux. Furthermore, according to the standards, all part of the room, even the side spaces, have received the enough daylight (70 lux).

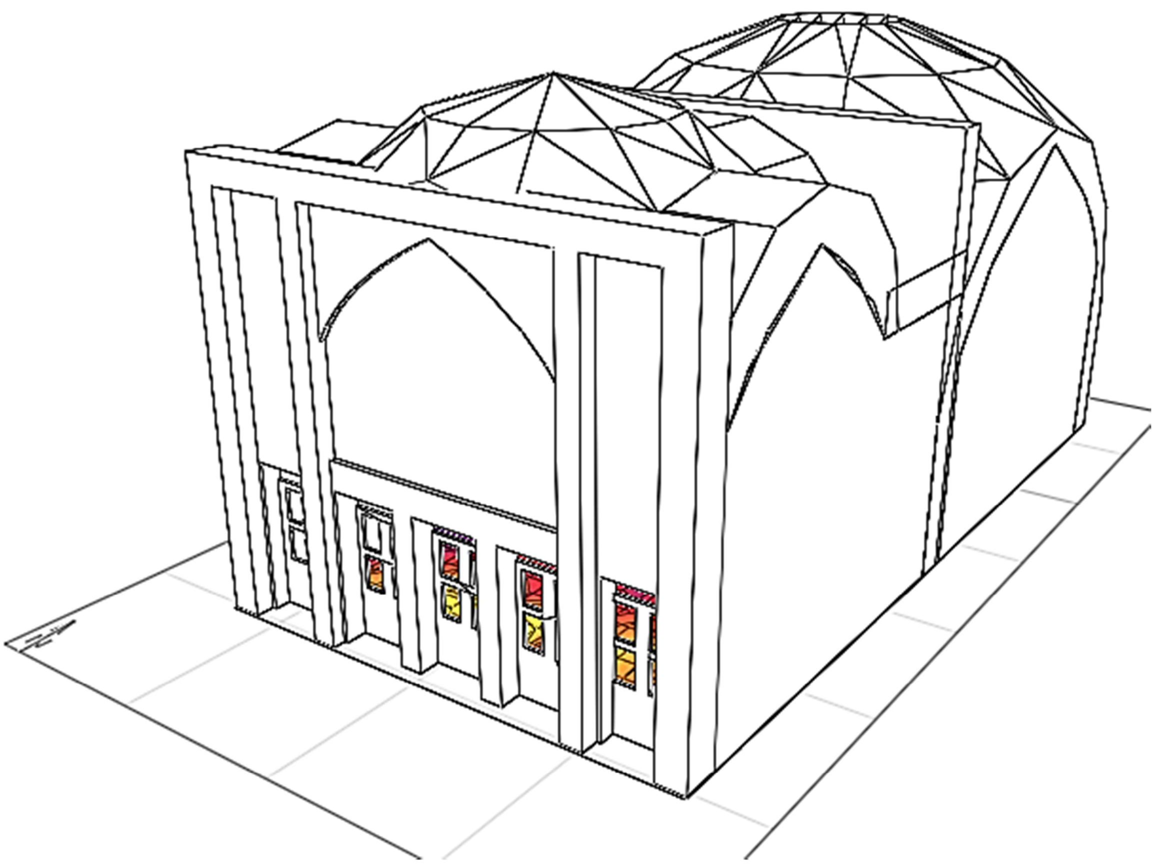


Figure 4-19: Case no. 3 presentation. Created by author

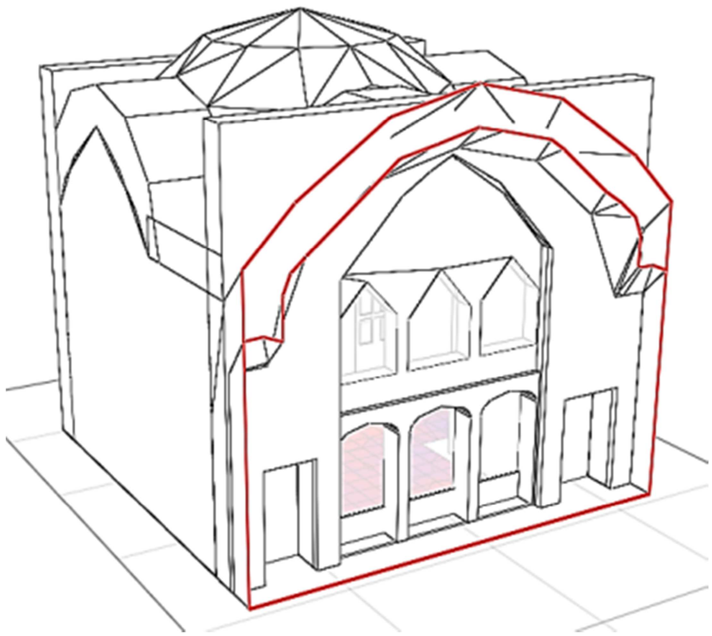


Figure 4-20: Case no. 3 presentation. Created by author

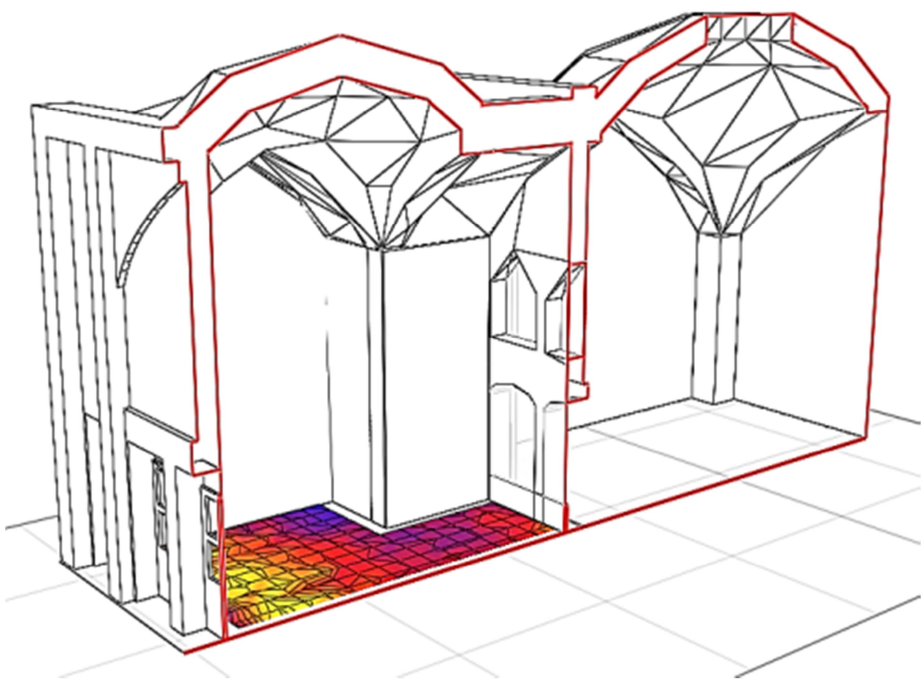


Figure 4-21: Case no. 3 presentation. Created by author

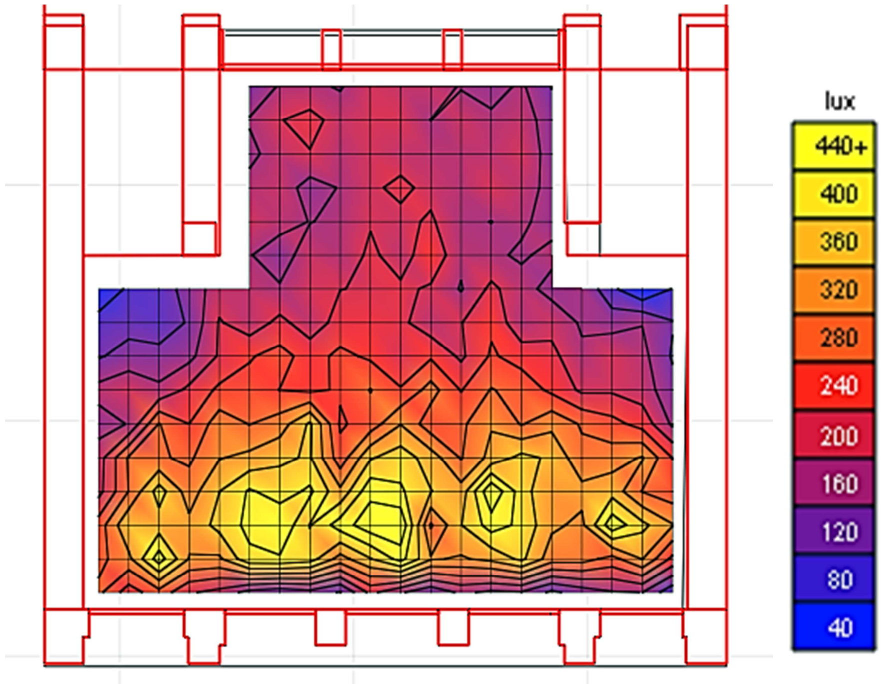


Figure 4-22: Horizontal daylight level analysis, case no. 3. Created by author

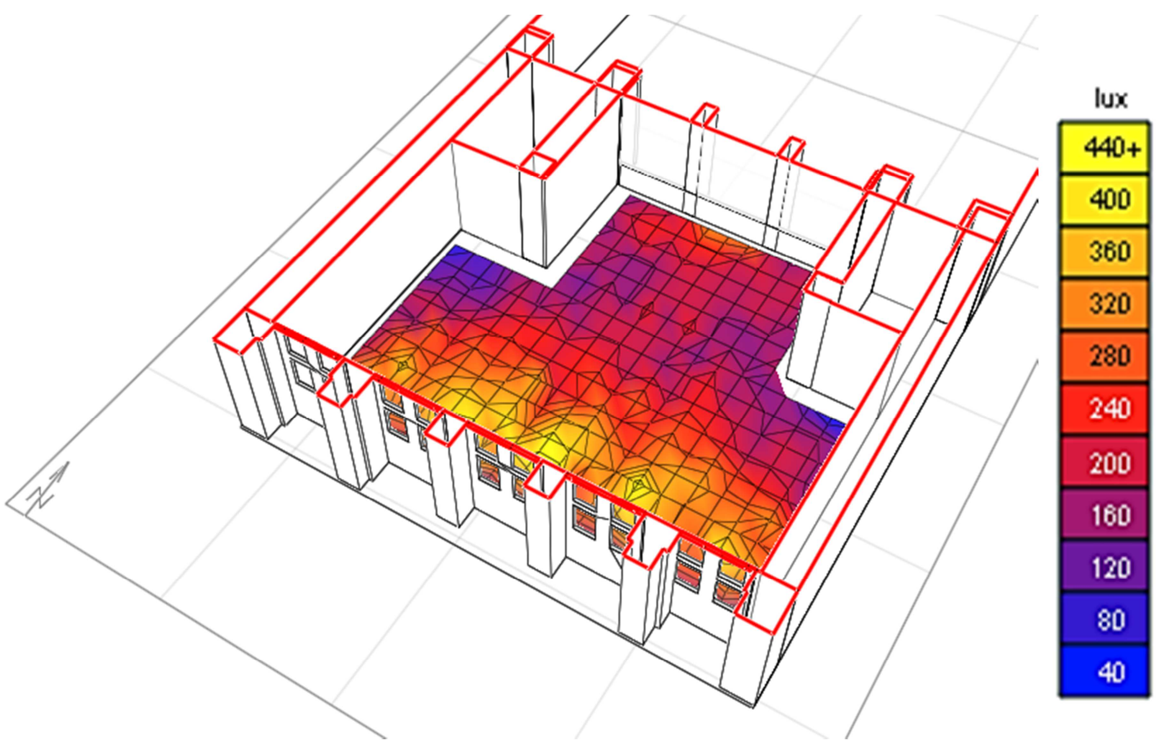


Figure 4-23: Horizontal daylight level analysis, case no. 3. Created by author

In the case no. 3, a variety of windows has brought daylight into the inside of the room. The room has faced south and rotated westward (around 10 degrees) in order to maximise daylight in the late afternoons like the case no. 1. Thus, in spite of the large scale of its interior space, the room has remained fairly well lit throughout the winter days until the late afternoon.

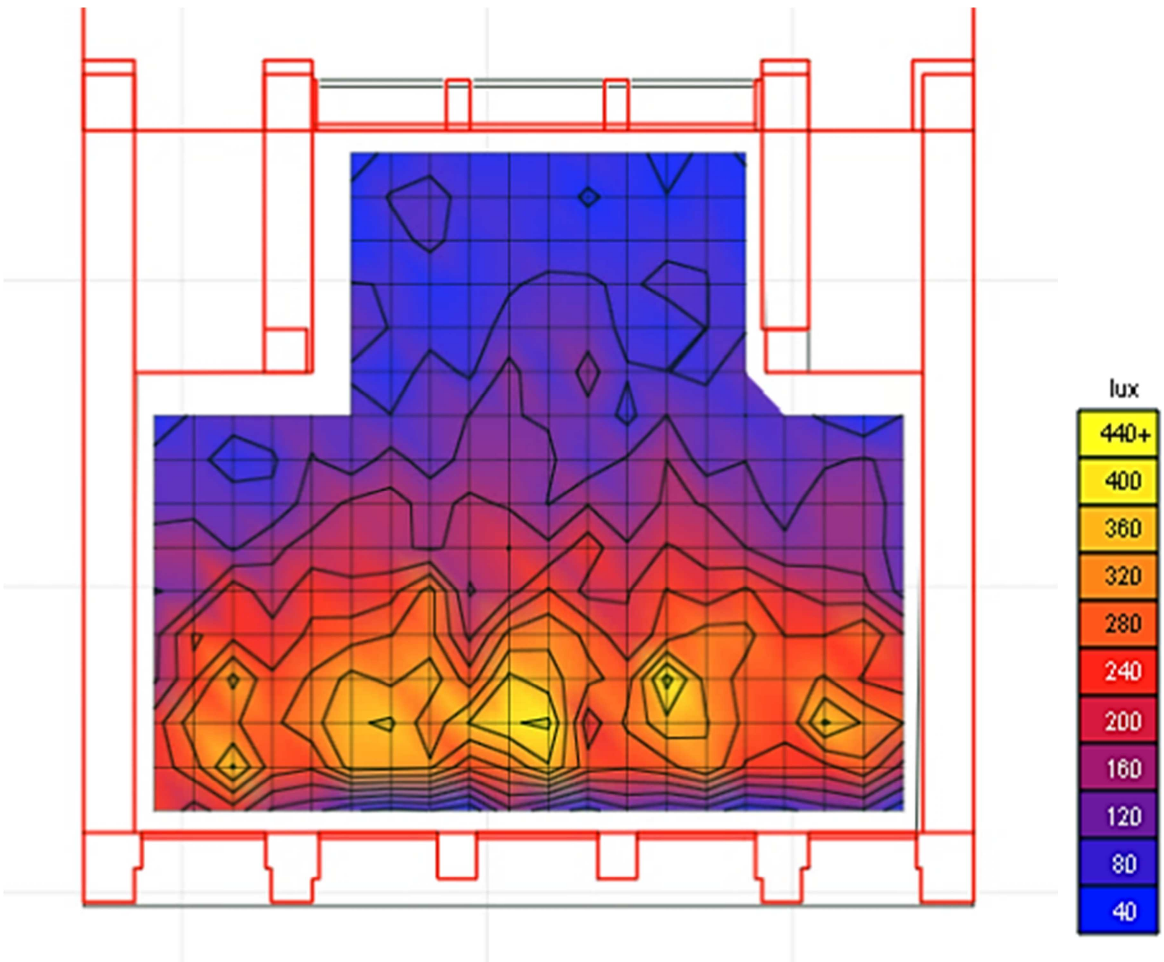


Figure 4-24: Hypothetical daylight level analysis, case no 3, northern windows close. Created by author

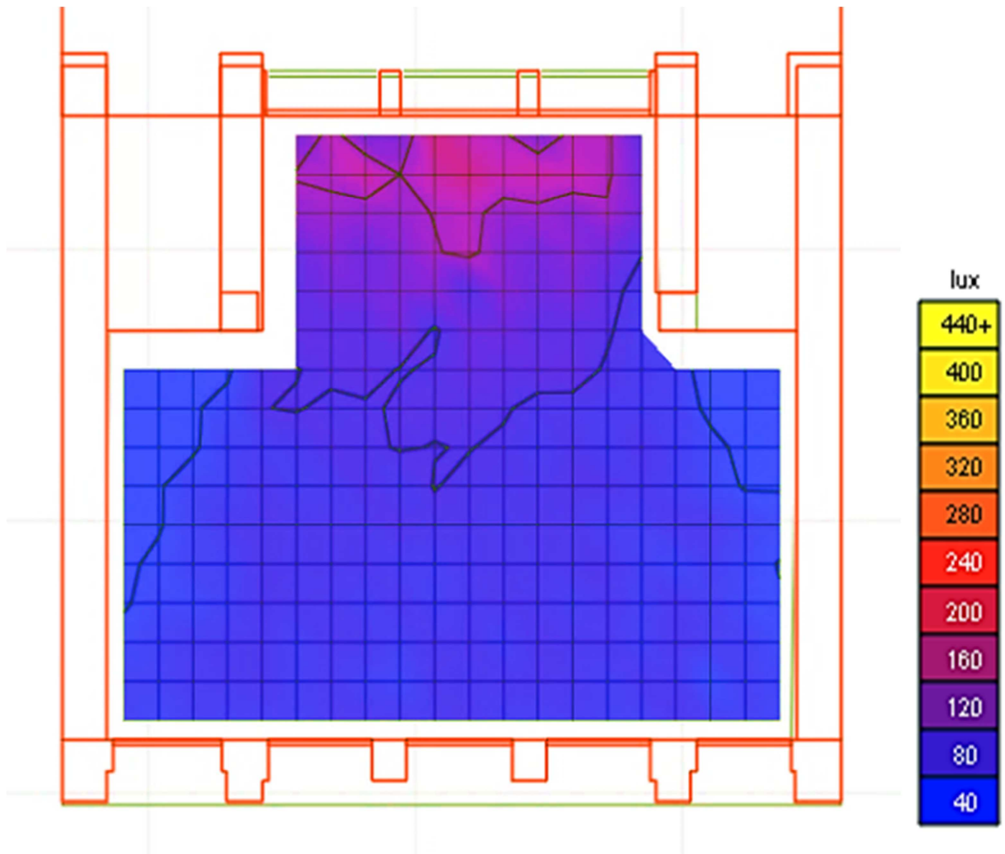


Figure 4-25: Hypothetical daylight level analysis, case no 3, southern windows close. Created by author

There were a plenty of windows in different shapes and sizes on the southern and northern walls of the room which have provided sufficient daylight. Daylight principally was provided through the long horizontal windows on the lower portion of south wall have which were dedicated to the front areas of the room. Therefore, the illumination is reduced gradually. Moreover, the two sets of horizontal lattice apertures within the lower and upper portion of the northern wall (backyard façade) have provided daylight for the back side of the room and augmented the visibility.

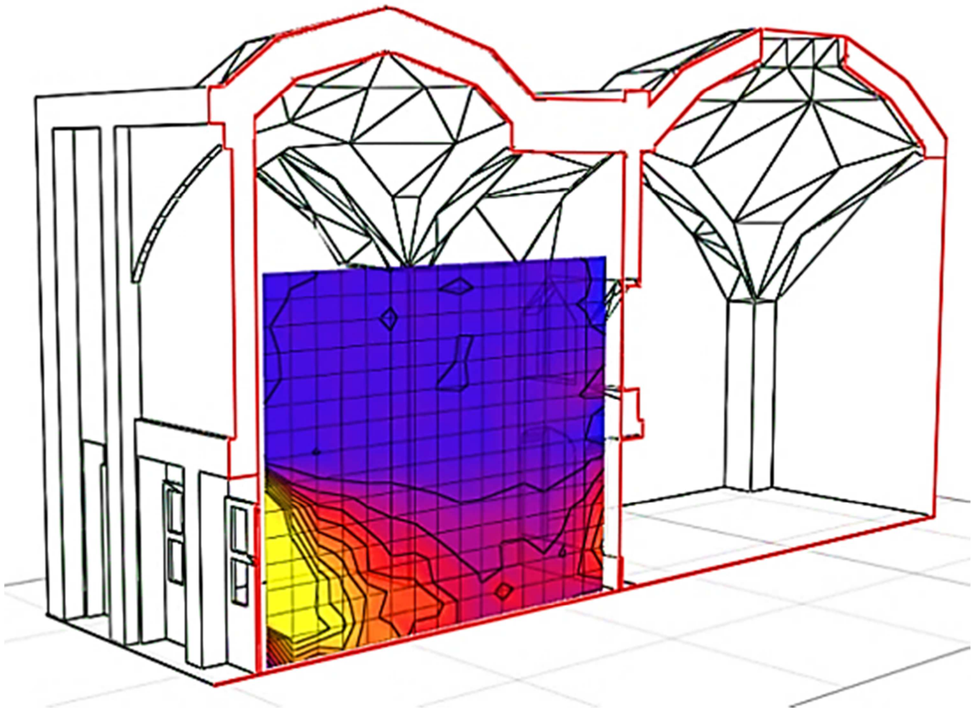


Figure 4-26: Vertical daylight level analysis, case no 3. Created by author

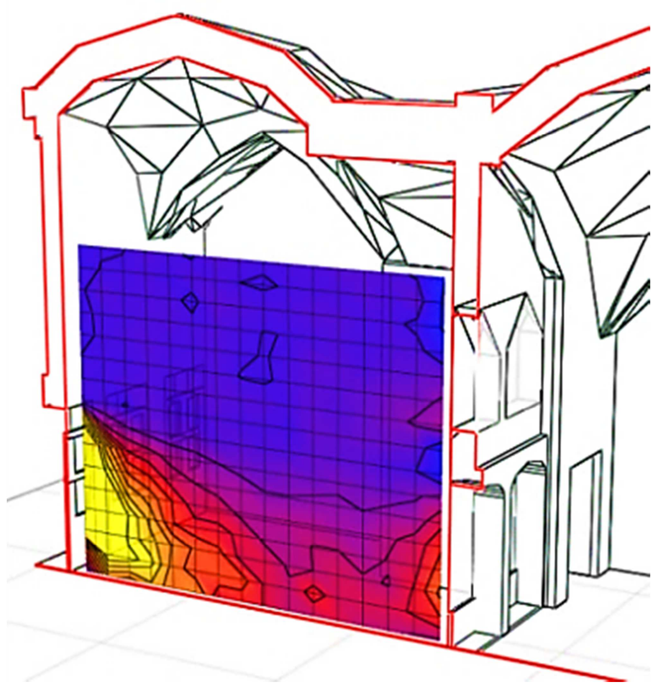


Figure 4-27: Vertical daylight level analysis, case no 3. Created by author

CHAPTER 5

5. Discussion of Findings

The history and architecture of Iran have influenced choices in daylight in both Iranian traditional and contemporary houses; however, contemporary social changes shift the priority to new and modern construction and the deficiency of quality daylight choices. In recent decades, the use of daylight has evolved with fundamental changes.

First, social changes have led to the immigration of people from small towns or rural areas to metropolises. The increase of population in metropolises and the lack of enough urban lands to build required residences to settle the newcomers have caused morphological changes in houses. The morphological changes in Iranian houses have changed the way of using daylight.

Second, the introduction of electricity and artificial lighting in Iran, which has provided enough illumination in most contemporary circumstances, has reduced the use of daylight in houses. Finally, the lack of knowledge about the important impacts of daylight on well-being has added to the decrease of the use of daylight in modern dwellings. As a result, reducing the use of daylight has decreased occupants' well-being which is correlated with the use of daylight.

Thus, by understanding the potential of daylight in enhancing well-being, the researcher was motivated to consider how increasing the use of daylight in residential buildings might be possible. In other words, since maximizing the use of daylight improves occupants' well-being, this research has aimed to understand using daylight as a means to enhance occupants' well-being.

In terms of traditional residential architecture, an exploration of the use of daylight throughout numerous years and in successive generations was done by examining the various techniques of benefiting from daylight. In this type of architecture, daylight was the principal source of lighting, and through an examination of its use, presents interesting solutions. Considering the wisdom of traditional residential architecture in terms of benefiting from daylight, the researcher has studied the traditional techniques of using daylight as a model to extrapolate its positive aspects. Considering its use for modern dwellings is then explored, in order to optimize the use of daylight and consequently to enhance occupants' well-being. In summary, this study has explored the research questions concerned with the use of daylight in Iranian courtyards, as a premise to understanding how to deal with daylight in contemporary Iranian houses. As we recall, the ***principal question of this research*** was: How to enhance well-being in Iranian modern dwellings through studying the techniques of using daylight in traditional houses? The ***secondary questions*** asked has included: Is it possible to optimize the use of daylight in modern dwellings through extrapolating the effective techniques of using daylight in traditional houses? And what are the effective techniques of using daylight in vernacular dwellings? Moreover, to what extent traditional daylight techniques were succeeded in bringing required illumination?

Summary of the Data Collection and Analysis of the Study

The process of responding to the research questions through studying the techniques of using daylight in Iranian traditional dwellings has highlighted the efficiency of the traditional techniques of using daylight and also indicated their positive aspects. Through the analysis of the data and evaluating daylight in traditional houses, findings have emerged that provide possible ways to consider optimizing the use of daylight to enhance occupants' well-being.

In this research in particular and to confirm and to support the research questions, a survey questionnaire was conducted. Through the survey questionnaire, Iranian experts' viewpoints about the main subject were collected and the shared issues were extracted. The participants were questioned about the importance of using daylight in the design process of dwellings, the current problems in terms of using daylight in dwellings which have decreased well-being and finally, the significance of daylight in traditional houses and the possibility of extrapolating the traditional techniques of using daylight into modern dwellings as a probable solution for current crises.

Then, three traditional houses were examined as case studies and the data examined elicited ways that daylight was enhanced in traditional dwellings. Therefore, through computer daylight simulation, the techniques of using daylight were analyzed and evaluated in each case and then compared to the other cases to elicit shared traditional techniques for benefiting from daylight. Since the climate of Iran is mostly arid or semi-arid and courtyard houses are the prevalent housing-type of this region, the case study choices of three traditional houses have focused on Iranian traditional courtyards. Based on the result of the survey questionnaire of Iranian experts, daylight of living rooms in winter days has emerged as a priority. The literature review has shown that the winter living rooms were used in dim winter days when there are the worst daylight conditions. In this weaker daylight conditions, the best measures must be taken into the winter living rooms to capture the daylight as much as possible. Hence, through this research, winter living rooms of traditional courtyard houses were analyzed as the selected study cells for this research. The cases were drawn two dimensionally and modeled through AutoCAD software. Then, they were analyzed through daylight simulation software, Autodesk Ecotect, in the worst-case design scenario based on an overcast sky distribution in mid-winter.

The emergent issue of the case studies were compared with the extracted data from the questionnaire to find out which one was very or less important. The salient issues, themes or ideas about using daylight in traditional houses were extracted to extrapolate to modern dwellings. Hence, this research not only has established a frame for presenting traditional techniques for using daylight in dwellings but also has provided a series of practical techniques to optimize the use of daylight in contemporary Iranian dwellings and as a result enhancing well-being.

5.1. Findings

Based on the findings extracted from the case studies, it was clarified that natural light levels obtained in traditional houses, during daylight hours, has met the contemporary standards of lighting in Iran. Hence, extrapolating the traditional techniques of using daylight into modern dwellings can be considered as a design option to optimize the use of daylight and as a consequence to enhance occupants' well-being in Iranian dwellings. The findings include the following characteristics that emerged:

- Orientation, layout and proportions of spaces as affecting daylight use;
- Location and size of windows;
- Control using lattices or windows;

- Effect of courtyards and backyards on the way daylight is captured;
- How spaces capture daylight - amount of daylight in the houses;
- Benefits of daylight in the traditional houses;
- Well-being of users affected by daylight in traditional houses.

Finally, the findings of the questionnaire have shown that more work needs to be done to understand contemporary homes and their lighting qualities and also how more traditional modes of lighting might be applicable to new home construction.

Results of the Case Studies

The findings of this research have shown that using daylight in traditional dwellings was in accordance with two crucial factors: first, the structure of these buildings and next, the functional pattern of users in them. Using daylight in traditional courtyards was in accordance with the structure of these houses. The traditional dwellings in hot-arid region which were studied through this research were mostly single or two story courtyards which were built of adobe or mud brick. They have had a courtyard in the middle that the rooms were arranged around its sides and have openings to it. But the changes occurred in the contemporary era have caused main structural changes in housing and transformed the one or two story traditional courtyards into today residential apartment. Thus, extrapolating the traditional techniques of using daylight in courtyards into contemporary houses may be imperfect without considering their existing structural differences and finding probable solutions for adapting the traditional techniques to cotemporary residential structure.

Results of the Interviews and Daylight Simulations

The results of the interviews have shown that daylight as the main lighting source in the traditional courtyards was considered as an influential element and played an important character in the design considerations of these houses. Meanwhile, the outcomes of daylight simulations were compared with the daylight standards of Iranian residential buildings and the comparison has shown that ample daylight was captured within the three case study houses. The final results have indicated that daylight has provided Iranian traditional houses with the required illumination according to the contemporary standards of lighting levels. In other words, the results have shown that the daylight in the traditional houses could provide enough illumination levels for doing variety tasks during daylight hours while the artificial light is absent.

Issues between the Traditional Approaches and Contemporary Realities

Furthermore, due to the contemporary social and culture reforms in recent years, lifestyles have changed. Indeed, what users have done in the traditional houses in the past are very different to what users do in apartment units nowadays. Considering that using daylight in traditional houses was in accordance with the functional pattern of users in these houses, bringing the traditional methods of using daylight into contemporary dwellings necessitates more attention to the changes. Hence, considering the impact of house structures and users activates on using daylight in Iranian traditional dwellings and considering the distinctions between contemporary houses and traditional dwellings in terms of structural and functional patterns, it may be essential to update the traditional techniques of using daylight and adapt these methods to the structural and functional changes of contemporary houses in order to be practical and useful.

5.1.1. Comparative Analysis of Interviews and Simulations

The data analyses conducted through the interviews and the simulations have revealed that the levels of daylight and its distribution depend on the various factors such as: the orientation, layout and proportions of spaces and moreover the location and size of widows and openings. These factors were considered to optimize daylight advantages in spaces through accurate consideration of the location of the sun. Indeed, Iranian traditional houses have optimized the use of daylight by accurate consideration of the orientation, layout and proportions of spaces as well as the location and size of openings.

The Orientation of Space

According to the findings of the simulations, the orientation of courtyards was generally northern-southern which was mostly due to climatic factors such as favourable or unfavourable winds and daylight; however, other factors like topography could be influential on orientation. Moreover, based on the geographical location of building, this orientation could be turned eastward or westward to increase the efficiency of buildings relative to climatic factors such as daylight. Considering the structure of courtyard houses, orientation was used to define the different climatic zones around the main courtyard as well as daylight zones (see Figure 5-1).

Orientation has allowed courtyard houses to have different daylight zones: in the northern, western, southern and eastern sides of courtyard. The northern quarters of courtyard has faced south and received more daylight. Conversely, the southern side has received no direct sunlight and it was mostly in shade. The western side has faced the east and received the sunlight early morning until the noon while the eastern side of courtyard receive intense sunlight during the afternoons and the evenings (see Figure 5-1).

Orientation was indicated by the participants of questionnaire as one of the important issues in design process of dwellings to optimize daylight use in spaces in the winter indicating that a well-orientated building can maximise daylight in the spaces and reduce significantly the need for using other lighting sources like artificial lighting during dim winter days. They have considered traditional dwellings as a successful sample and mentioned that the orientation of traditional dwellings was one of their inherit features in terms of benefiting from passive resources as well as sunlight.

The participants have stated that the orientation of traditional houses was determined by geographical and climatic factors such as land geometry, wind and the direction of daylight. Indeed, the participants have believed that the orientation of buildings was considered as a practical strategy in traditional dwellings for benefiting from natural potential and resources including daylight. This fact has shown the great influence of daylight on the design process of Iranian traditional dwellings.

The Layout and Proportion of Space

According to the results of the simulations, the layout of spaces around the courtyard was based on their need to the daylight. Indeed, spaces according to their needs to daylight were situated in appropriate daylight zones that were defined by the orientation of courtyard (see Figure 5-1). For example, spaces which were used during the winter and needed the more daylight were located in northern side of courtyards facing south. Therefore, horizontal sunlight has penetrated even to the deepest parts of spaces and resulted in lightening spaces completely during the dim winter days.

By contrast, summer spaces, located on the opposite side of courtyard (southern side), have reduced sunlight penetration and consequently decreased heating in spaces. Similarly, spaces were located in proper places based on their priority in using daylight. In the eastern and western parts, other spaces with regard to their need to daylight were situated; western spaces have faced east and received the early morning sunlight. The western spaces were used in the mornings during the summer or the warmer spring and autumn days. Meanwhile, the eastern spaces of courtyards that have received intense sunlight during the afternoons and the evenings were considered for service spaces (see Figure 5-1).

Participants mention how the layout of spaces is a key factor which has had influence on the use of daylight. The participants consider daylight as a key factor in determining the layout of spaces in courtyards, and some mention that layout was mostly due to the priority of spaces in using daylight. They have stated that spaces based on their needs to daylight were situated in separate lighting zones defined by the orientation of courtyard; since different spaces of building have not needed equal access to the sun, spaces which have required more daylight were located on sides which have faced the sun and the other spaces were situated on the other sides. For instance, spaces like living spaces and rest spaces which required more daylight have located on areas facing south and spaces that rarely have needed daylight, like service areas, were located on the eastern side far away from daylight spaces (see Figure 5-1).

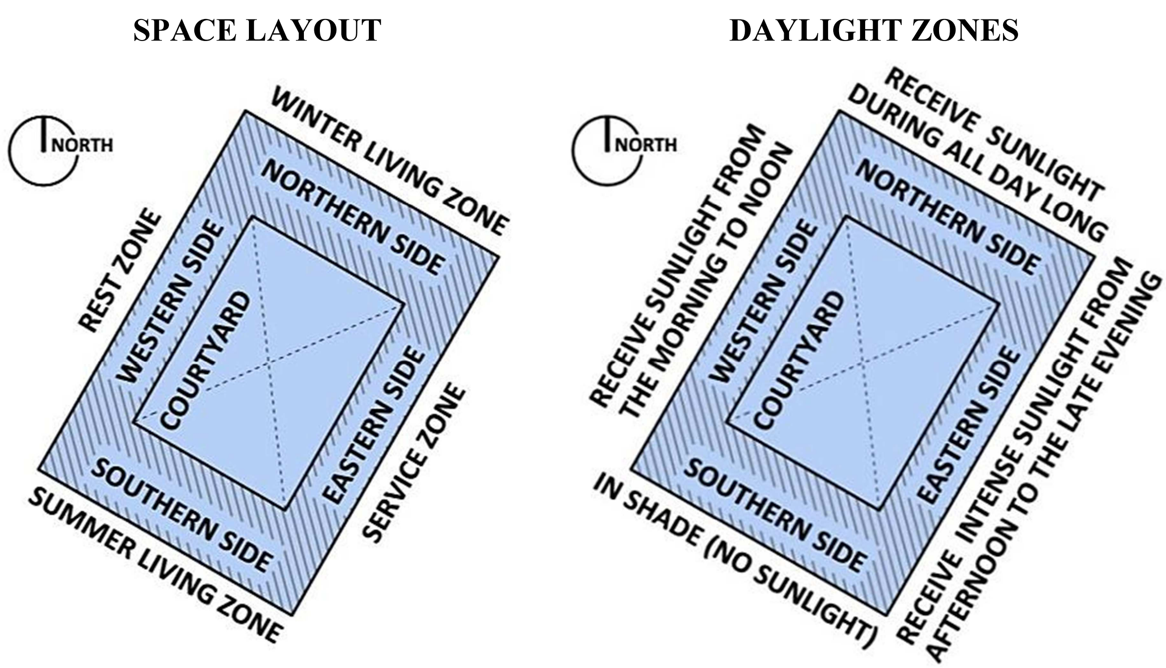


Figure 5-1: Spaces layout and daylight zones in courtyard. Drawn by author

Furthermore, the findings of the interviews and the daylight simulations have shown a significant correlation between the proportion of spaces and the use of daylight in traditional courtyards. In fact, the proportion of spaces was determined to optimize the use of the daylight in spaces. For example, spaces which have located in winter living zone on the northern side of courtyard were deeper than other spaces. Indeed, locating spaces in the northern quarters has led to receive horizontal winter sunlight during the winter and to benefit from daylight even in the deepest areas of space.

The Location, Size and Characteristics of Windows and Openings

According to the findings of simulations, windows and opening were other factors that have impacted on the use of daylight in traditional residential buildings. The location of openings was determined to provide sufficient daylight in spaces although other factors such as view, heat gain and loss and glare have had bearing on this process. The size of openings is affect by factors such as the proportions of spaces and moreover the amount of daylight which was required in each space. Furthermore, the form of windows and openings has played a significant role in adjusting daylight in spaces. Windows either simple or lattice with colour glasses or not, single or double glazing have has an important influence on daylight penetration, fragmentation and distribution of daylight within spaces.

Similarly, windows and openings were stated as effective elements by the participants of the questionnaire referring the influences of their location and their size on the amount of daylight that spaces have received. Furthermore, as another minor advantage, entering daylight through windows has provided spaces with a view from outside. The participants have believed that windows and openings have connected the indoor to the outdoor world and acted as a frame for capturing what has happened outside. Furthermore, the participants have mentioned to some other side effects which have had great impacts on participants physically and physiologically including occupants' well-being. For instance, the participants have mentioned that using daylight in spaces and providing a view from outside significantly reduced the depression.

SALIENT ISSUES		**SHARED ISSUES**
SIMULATIONS	INTERVIEWS	
–provided lighting levels around 200-250 lux –general southern-northern orientation in cases –westward rotation (about 20°) to optimize daylight use –winter daylight zones on northern side of courtyard –golden proportion in design of spaces and windows –principal openings on the southern wall –windows on northern wall to provide daylight in extended areas –lattice windows to provide privacy –provided view to courtyard and backyard	–daylight as an important element –space orientation –space layout –space proportion –windows location and size –views –enhanced well-being –energy savings –privacy –legislative norms on building –"build and sell" issues –success –unique structural features –issue of lifestyle affecting its usefulness –update current using ideas of traditional architecture	–daylight as an important element in design –space orientation, southern-northern, rotated westward about 20° –spaces layout, winter zone located on northern side of courtyard to benefit from winter daylight –spaces proportion, followed golden proportion derived from a golden rectangular –windows location, principal windows facing south, windows on northern part provided daylight in extended area –windows layout, followed a continuous punched pattern –windows size, followed golden proportion –privacy, lattice windows to provide enough privacy –separate functional and structural pattern in courtyard than modern houses, required to be adapted and updated

Table 5-1: Salient issues extracted from the simulations and the interviews. Created by author

5.1.2. Emergent Data Analysis of Three Houses

The data analyses which done through the research have revealed that the levels and distribution of daylight have depended on the various factors such as: the orientation, layout and proportions of spaces and moreover the location and size of widows and openings. In traditional houses, these factors were considered to optimize the use of daylight in spaces through understanding the accurate location of the sun. In other words, Iranian traditional houses have provided the possibility of optimizing the use of daylight through the accurate consideration of the orientation, layout and proportions of spaces and moreover the location and size of openings.

The Orientation and Location of Space

The daylight analyses of the cases through simulation software have shown that the orientation of the cases has made a huge difference in the degree to which daylight is received and its quality. Since the cases were located on the northern side of courtyard and faced south, they have received potentially enough sunlight through the winter days. However, the westward rotation of the northern-southern orientation (10 and 20 degrees) of two cases (case no. 1 and 3) has allowed taking advantage of sunlight until the last minute of a dim winter day (see Table 5-2).

Considering the limited amount of sunlight due to the low position of the sun during the winter, this westward rotation has caused to benefit from daylight as much as possible. But inversed rotation in another case (case no. 2) has resulted in receiving less daylight in the same time (see Table 5-3). In this case, the dominant southern-northern orientation has followed an eastward rotation (around 10 degrees). Since this eastward rotation has limited daylight penetration in the evenings and considering that this case was situated in the same location as case no.1 and case no.3, this inversed rotation may have been under influence of other factor such as topography.

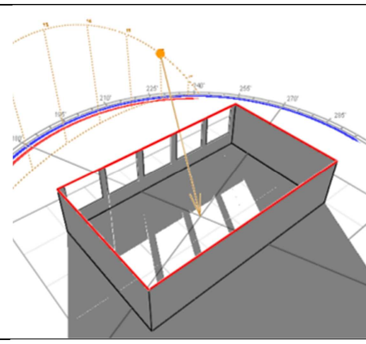
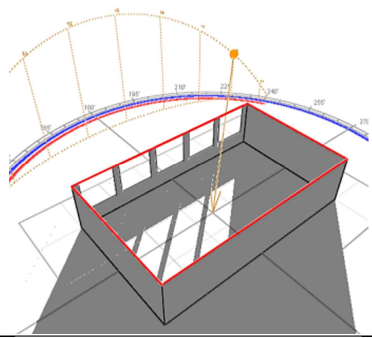
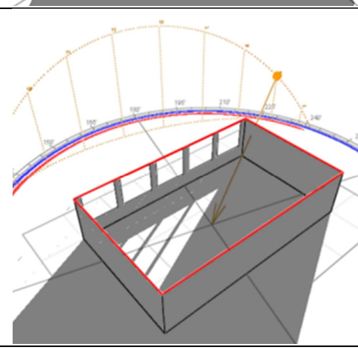
Southern-Northern Orientation			
	20° westward rotation	Case No. 1 and 3	
	No rotation		
	20° eastward rotation	Case No. 2	

Table 5-2: The rotation of southern-northern orientation. Analysis has done for an imaginary case which is located in Kashan on winter solstice (December 21st) at 4 PM; Winter solstice is the shortest day of the year. The analysis was done one hour before the sunset. Created by author

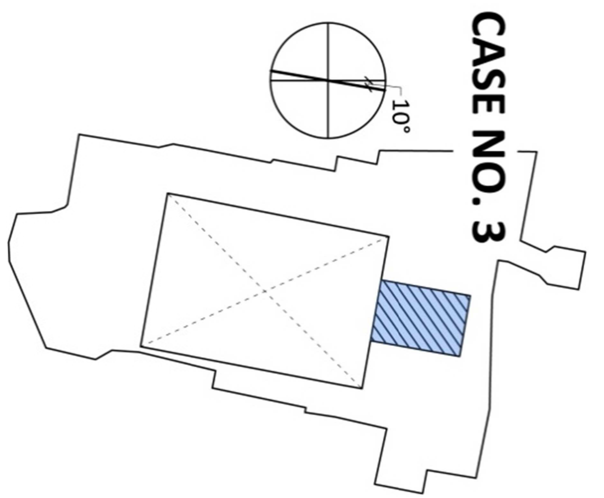
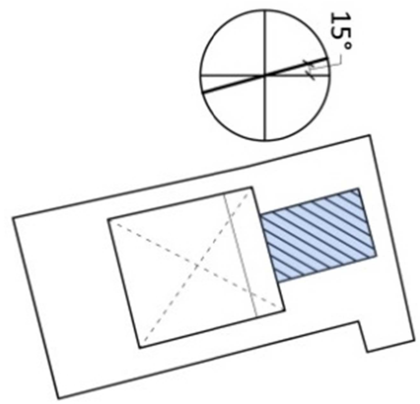
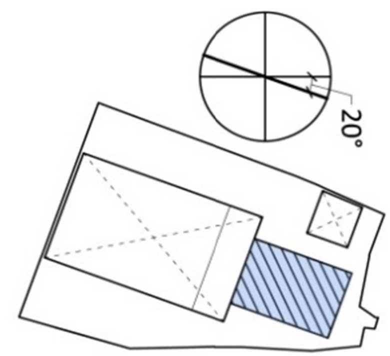
The Orientation of Cases		
CASE NO. 3	CASE NO. 2	CASE NO. 1
10º westward	15º eastward	20º westward
		

Table 5-3: Northern-southern orientation in the cases. Drawn by author

The Proportion of Space

Moreover, the analysis of daylight simulation in the selected cases has shown that the proportions of spaces have played an important role in terms of daylight benefits. The analyses have shown that the depth of a space has played an important character in good daylight distribution within spaces. Therefore, walls located in the opposite side were considered relatively close to windows. Alternatively, when the depth of spaces has increased openings that have faced to backyard bring in the required daylight to the distant parts of spaces.

Furthermore, the analysis of all study cases has shown that the proportions of spaces have derived from a golden rectangle (see Figure 5-2 and Table 5-5). When creating golden rectangle geometry, first a square ABCD is drawn. Then, from C and with radius CB (the square's diameter) an arc is drawn, CA is extended and crossed the arc at E (step 1). Then, a perpendicular to CE at E is drawn (step 2) and then DB is extended to intersect the perpendicular at F (step 3). EDEF is a Golden Rectangle (Figure 5-2).

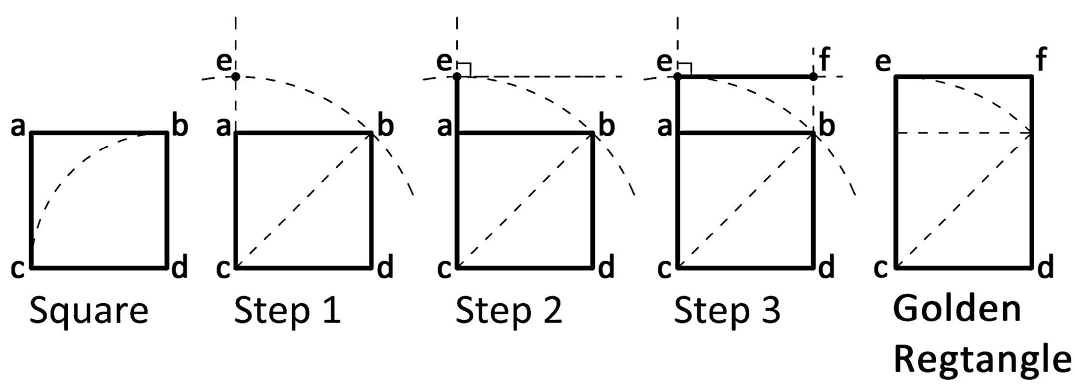


Figure 5-2: The process of drawing a golden rectangular. Drawn by author

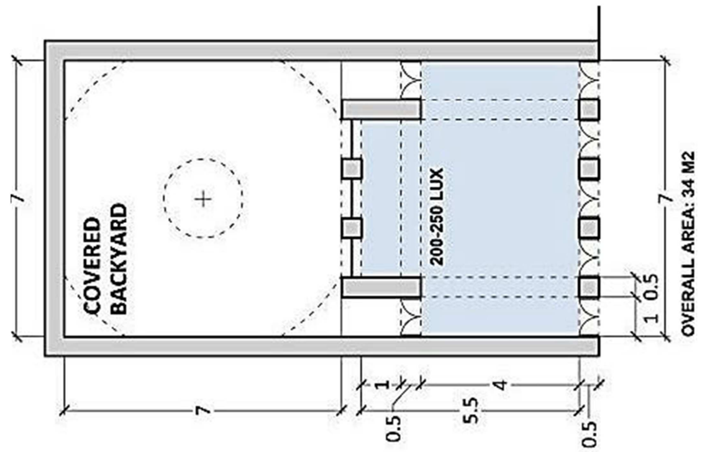
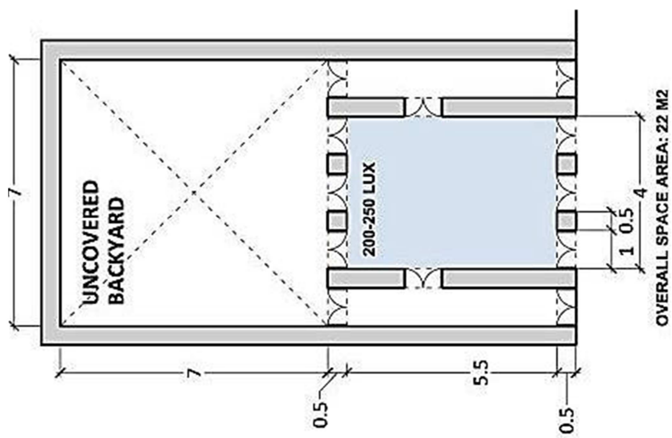
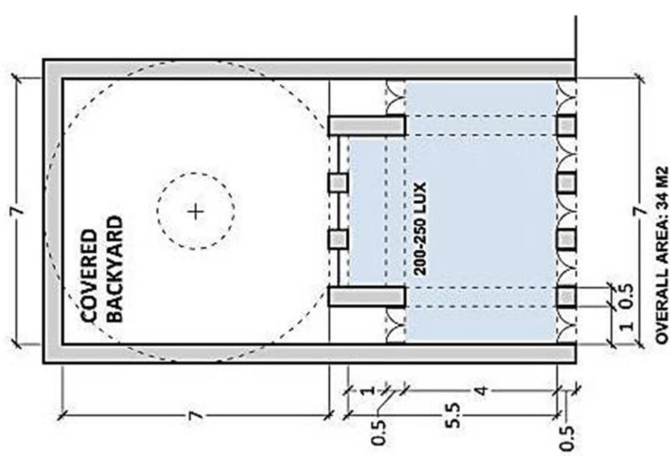
CASE	PROPORTION OF SPACES	SPACE DIMENSIONS
CASE NO. 1		length: 7 m depth: 5.5 m height: 6 m
CASE NO. 2		length: 4 m depth: 5.5 m height: 4 m
CASE NO. 3		length: 7 m depth: 5.5 m height: 7 m

Table 5-4: The proportions of spaces in the three study cases in plan. Drawn by author

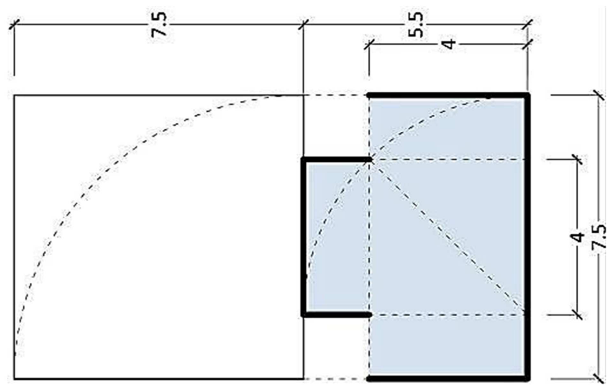
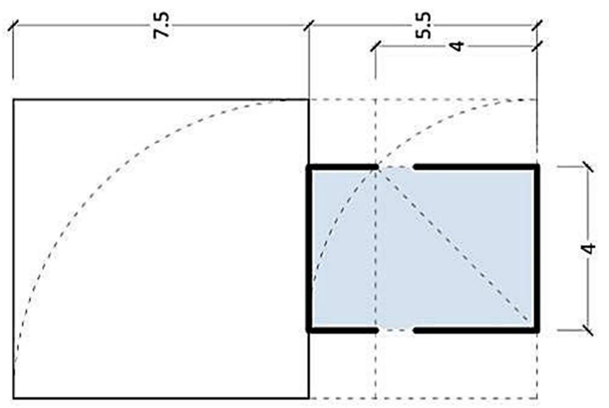
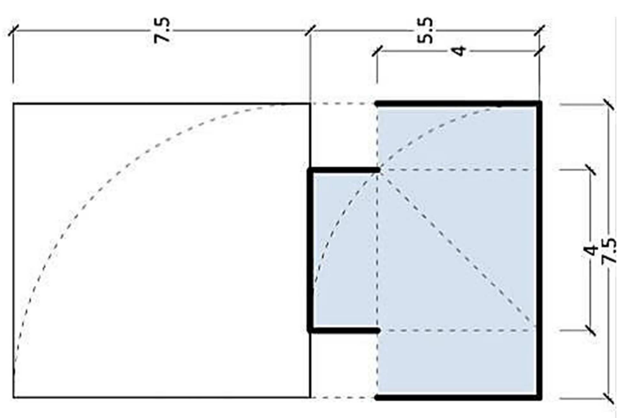
CASE	GOLDEN PROPORTIONS OF SPACES	SPACE DIMENSIONS
CASE NO. 1		length: 7 m depth: 5.5 m height: 6 m
CASE NO. 2		length: 4 m depth: 5.5 m height: 4 m
CASE NO. 3		length: 7 m depth: 5.5 m height: 7 m

Table 5-5: The golden proportions of spaces in the three study cases. Drawn by author

The Location, Size and Characteristics of Windows

The analysis of daylight simulation has shown that the orientation, size, layout and the performance characteristics of windows have played a significant role in benefiting from daylight in each case. This was the most important part, because it has incorporated daylight distribution within spaces. Moreover, it was essential to consider the specifications of windows including the nature of glazing, its transmission value and other characteristics.

The result extracted from this study has mentioned that the windows in courtyard houses have followed specific proportions (derived from a golden rectangular similar to proportions of spaces). While, the orientation, size, layout and performance characteristics of windows have played a noteworthy role in controlling daylight in courtyard houses, using specific proportions in the design of spaces and windows may have been to harmonize the amount of daylight. Furthermore, based on data extracted from literature review, unit that was utilized in the design of courtyard houses has derive from human scales, such as the distance from fingers to elbow (approximately 0.5 m) or an open hand (approximately 0.25 m) in a medium size person.

The analysis of the three study cases has shown that in living winter rooms of courtyard houses: firstly, the layout and size of windows were typical (Table 5-6); windows on courtyard façade have followed the same dimensions which have derived from the dimensions of a golden rectangle (width: 1 meter, height: 1.5 meter) (see Appendix VI). Meanwhile, on the backyard elevation, lattice apertures have followed either same dimensions as windows on courtyard façade or they have kept the same width but their length has become larger (width: 1 meter, height: 2.5 meter) (see Appendix VI). Secondly, the layout of windows has followed a continuous punched pattern, with 0.5 meter break between each two windows, on two sides (courtyard and backyard façade); therefore, outer wall was divided equally in three or five parts (it is always an odd number) and each part has contained a typical window.

Finally, on courtyard wall, windows were single glazing; while, on other side, adjacent to covered backyard, they are mostly lattice, although they were single glazing in the case no. 2 which has had an uncovered backyard. lattice windows have followed the same dimensions when they were located on the lower part of backyard wall in the case no. 1 and no.3 (width: 1 meter, height: 2.5 meter) but in the case no. 3 when they were situated on the upper side of backyard wall, their size was reduced and followed the same size as windows on courtyard wall (width: 1 meter, height: 1.5 meter). Single glazing windows which were located on the lower part of backyard elevation in the case no. 2 have followed the same dimensions as windows on the courtyard wall (see Appendix VI).

Moreover, the penetration of daylight in spaces has varied by windows head height. For instance, placing windows on the higher part of courtyard wall (windows head height: 4.25 meter) in the case no. 1 has caused deeper daylight penetration into spaces. Conversely, in the case no. 3, locating windows with the same size lower (windows head height: 1 meter) has resulted in decreasing the depth of daylight zone. Hence, for providing enough illumination in the extended areas of the case no. 2, adjacent to backyard, two rows of lattice apertures were used instead of one in the case no. 3 (see Appendix VI).

Although, the minimum required daylight (70 lux) were provided in the extended areas through the backyard lattice apertures; but since this amount of daylight were inadequate due to covered adjacent zone (backyard), the researcher believes that considering the lattice apertures on the backyard wall has followed other reasons, perhaps thermal or visual besides daylight-based reasons.

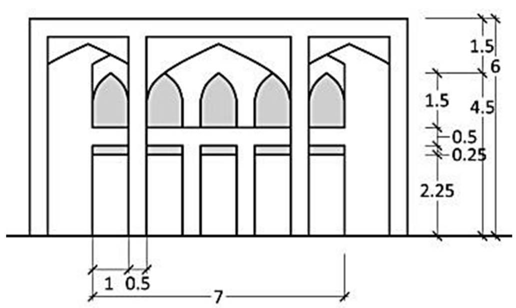
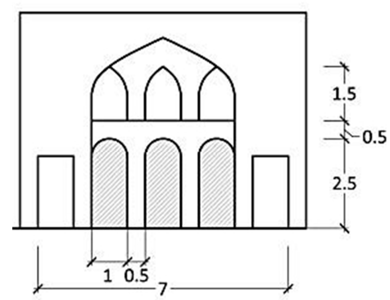
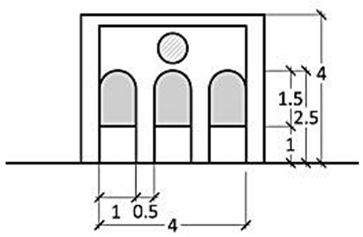
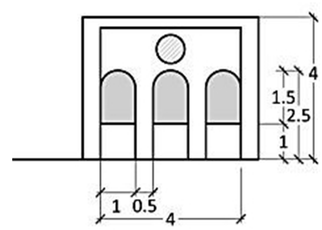
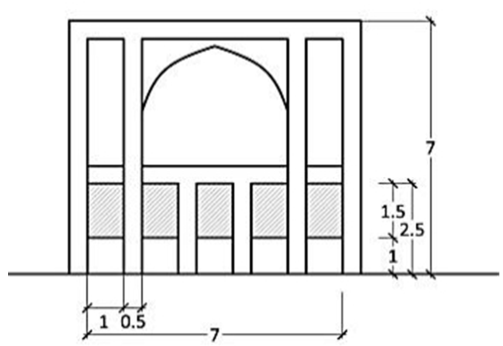
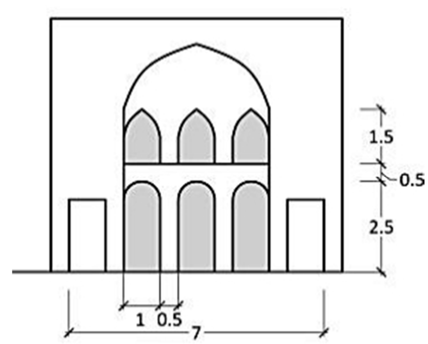
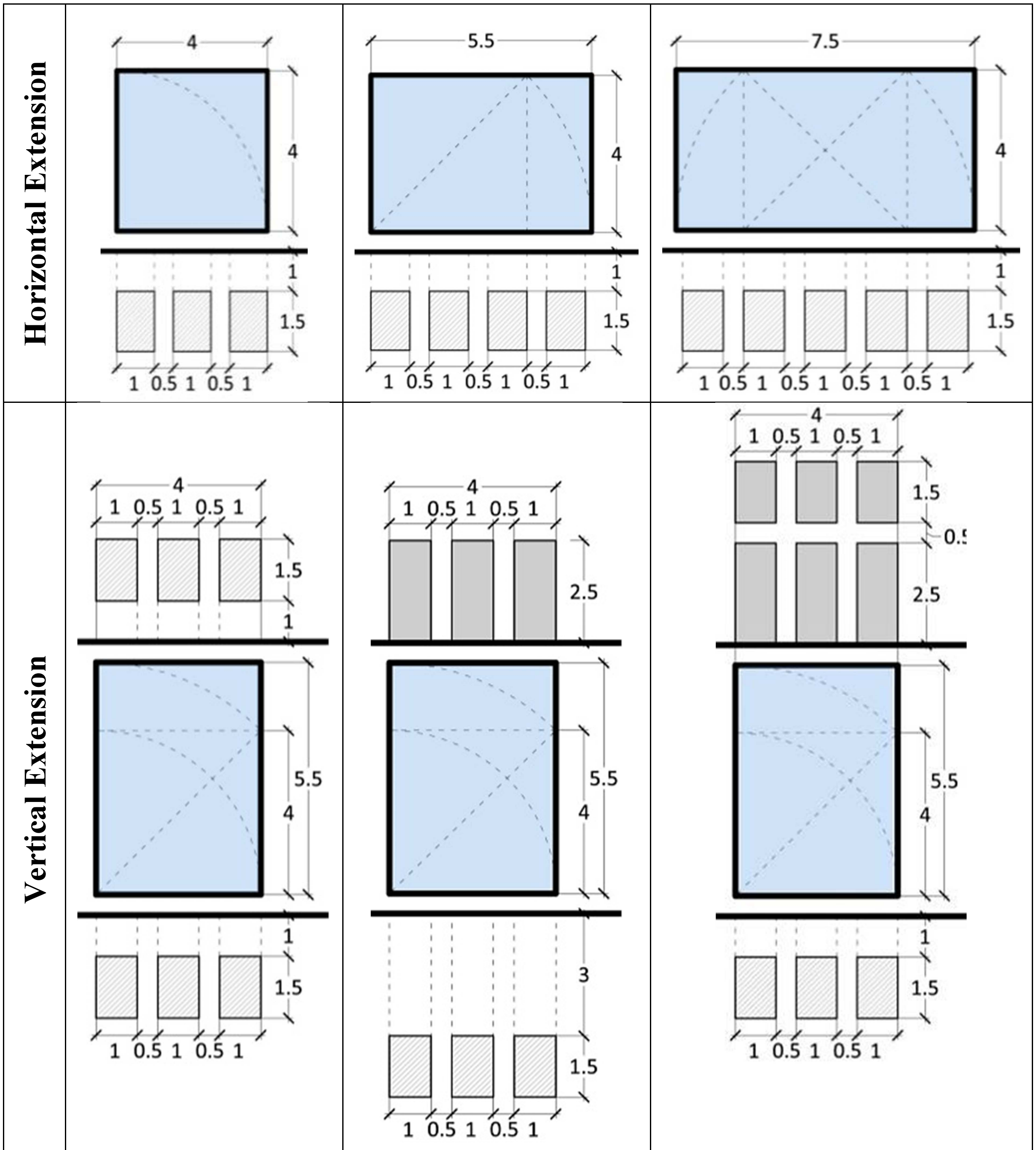
	Courtyard Elevation	Backyard Elevation
Case No. 1		
Case No. 2		
Case No. 3		

Table 5-6: The elevations of the three study cases in . Drawn by author

The Simplified Patterns of Using Daylight in Winter Living Rooms

The pattern of benefiting from daylight in winter living rooms of traditional courtyards may be simplified as has shown below (see Table 5-7); considering that in each pattern an approximate 20 degree rotation should be applied. In the first row, the patterns of using daylight in the principal part of space were presented; in this case, extended area was ignored. Hence, required illumination for principal part was provided through windows located on southern wall. The second row has shown when an extended area was included; in these patterns, extra windows on northern wall have provided enough daylight for extended area via backyard.

Finally, as the analysis has shown, the orientation, layout and proportions of studied spaces besides the location, size and characteristics of their windows, have had a significant impact on the penetration of daylight and its distribution within spaces. General northern-southern orientation which has turned westward not only has maximized the penetration of daylight into spaces but also the use of daylight until the last moment of a dim winter day. Moreover, the proportions of paces have had a great impact on uniform daylight distribution within spaces. Walls located in the opposite side of courtyard façade were considered relatively near windows. When the depth of spaces has increased, daylight was provided within extended areas through extra windows on backyard façade. Meanwhile, the location and size of windows as well as their characteristics have played an important role in the penetration and distribution of daylight into spaces. For instance, placing windows on the upper or lower part of walls has had a considerable bearing on the distribution of daylight within spaces. Similarly, the characteristics of glazing could increase and decrease the amount of daylight.



dark gray windows: lattice aperture
bright gray windows single glazing

Table 5-7: Simplified patterns of using daylight in winter living rooms.By author

5.2. Summary of the Findings

Based on the findings that were extracted from this research through the literature review, the questionnaire and daylight simulation, it becomes clear that the extrapolation of the techniques of using daylight in traditional courtyards houses into modern dwellings can be considered as a design option to optimize the use of daylight and as a result to enhance occupants' well-being. However, the findings also show that more work needs to be done to understand modern homes and their lighting qualities, and to understand how traditional modes of lighting might be used to enhance new home construction.

The findings have revealed that using daylight in traditional courtyard houses were in accordance with two important factors: first, the structure of these buildings and next, the functional pattern and use of the spaces by the users. Social changes occurred in the contemporary era have also changed housing and lifestyle. Therefore, before extrapolating the traditional techniques of using daylight into modern houses, it may be essential to update these methods and adapt them to the new structural and functional of patterns in contemporary houses.

Moreover, the findings have showed that the average of illuminance in the studied winter living rooms was around 200-250 lux which is in accordance with to the suggested lighting standards of living rooms in modern residential buildings in Iran (200 lux). In addition, according to these standards, there has existed barely a point which did not receive enough daylight (70 lux), even in the worst-case design scenario.

The findings have revealed that the levels and distribution of daylight in traditional courtyards have depended on the various factors. These factors were used to optimize the use of daylight such as:

The Orientation and Location of Space

The findings have showed that the location and orientation of spaces in traditional houses were based on climatic conditions. Intensified sunlight changes have shaped traditional courtyards along with a north-south orientation. This orientation has allowed the courtyard houses to have two different daylight zones: one is in the north side of courtyard and other one is in south side. Winter livings room was situated in the northern quarter of courtyard facing south and receiving more daylight; thus, it was suitable for dim winter days.

The general southern-northern orientation of winter living rooms has had a westward rotation (approximately20 degrees). Considering the limited amount of daylight due to the position of the sun during the winter, this 20 degree westward rotation has caused to benefit from daylight until the last minutes of a winter day.

The Proportions of Space

The proportions of spaces were another feature. The preparation of minimum required illumination even in the darkest sides was considered. Walls which were located in front of windows were relatively near to windows. Alternatively, when the depth of spaces has increased, openings which faced to covered backyards have brought required daylight into the distant parts of winter living room. Moreover, the proportions of winter living rooms have derived from a golden rectangle. Using these proportions in the design process of courtyard houses may have been to harmonize the amount of daylight.

The Layout, Size and Specifications of Windows

Based on the findings of this research, the layout, size and performance characteristics of windows have played a significant role in the penetration of daylight into spaces. It was the most complicated part, because it must have incorporated the daylight distribution within spaces. Moreover, the specifications of windows and openings, including the nature of glazing, its transmission value and other characteristics were considered base on the required illumination in spaces.

The size and layout of windows and openings are typical; windows on courtyard façade have followed the same dimensions which have derived from the proportion of a golden rectangle. In the meanwhile, on backyard façade, lattice apertures have followed the same dimensions or they were larger in length keeping the same width. Furthermore, the windows layout has followed a continuous punched pattern. On courtyard façade, windows were single glazing; while, on the other side, adjacent to covered backyard, they were mostly lattice.

SUMMARY

The traditional techniques for using daylight in courtyard houses including the orientation, layout and proportions of spaces and the location, dimensions of windows in addition to the features of glazing all used to optimize the use of daylight in traditional spaces. Since optimizing the use of daylight in residential dwellings leads to enhancing occupants' well-being, studying and understanding the techniques of using daylight in traditional courtyard houses and extrapolating these techniques into contemporary houses can increase the use of daylight in contemporary houses and as a consequence improves their occupants' well-being; while, as it was discussed, the cotemporary changes which were happened in the last several decades have reduced significantly the use of daylight in contemporary houses and as a result decreased occupants' well-being. Thus, studying daylight and the techniques of using daylight in traditional courtyards as a model and extrapolating these traditional techniques into contemporary houses may optimize the use of daylight in contemporary houses and enhance occupants' well-being.

CHAPTER 6

6. Conclusion

Iran's contact with the Western countries has increased in the contemporary era and acquaintance with modernization and industrialization in these countries has encouraged Iranian governors and authorities to follow wide spread principal social and cultural changes in Iran. These social and industrial developments in metropolitan areas have increased immigration from small town and rural areas to these cities. Consequent population increases in metropolitan areas has necessitated providing newcomers with enough dwellings as places to live. Meanwhile, the lack of enough urban lands to build sufficient residences has led to morphological changes in Iranian traditional dwellings. Hence, the morphological changes have also affected not only building design but consequently the use of daylight in contemporary dwellings.

Furthermore, artificial lighting as a new source of lighting was introduced and soon become very popular in the contemporary era, providing adequate illumination in most modern circumstances. All these benefits, in addition, the lack of knowledge about the important impacts of daylight on occupants' well-being have had an impact on the use of daylight. Therefore, the resultant decrease in the use of daylight has an effect on users' well-being.

Understanding the capacity of daylight in enhancing occupants' well-being has motivated the researcher to think about increasing the use of daylight in Iranian dwellings in order to enhance well-being. Meanwhile, the wisdom of traditional dwellings in using daylight and the importance of daylight in these houses when it was used as the principal source of lighting have encouraged the researcher to study the techniques of using daylight in traditional dwellings as a model to extrapolate its positive aspects to modern dwellings to increase the use of daylight in these houses and as a consequence to increase well-being.

To establish, confirm, support and detail the research questions, the data collection and analysis proceeded in two phases. First, with two data collection sections: 1.literature review, and 2.survey questionnaire. Through literature review, the recognized features of using daylight in Iranian traditional houses were studied; the idea includes considering how to enhance well-being by increasing the use of daylight in modern dwellings. Second, through survey questionnaire, Iranian experts' opinions on the main subject were collected and the shared issues were extracted.

For the second phase of the data collection and analysis, and to answer the principal question of this study, the case study of three traditional houses in Iran was conducted. The research has aimed to elicit and understand techniques of using daylight in separate traditional dwellings to construct the shared traditional techniques of using daylight based on the researcher's interpretation. Hence, through computer daylight simulation three different traditional courtyards were analyzed and evaluated.

Finally, in the data analysis phase, the emergent themes were compared to extracted data from interviews to find out which one was very or less important. By using these documented aspects in this study, the salient issues, themes or ideas about using daylight in traditional houses were extracted to extrapolate to the future dwellings.

The process of responding to the research questions has highlighted the significance of using daylight in traditional dwellings indicating the efficiency of using daylight in these houses through computer simulation. Then, traditional houses and their appropriate techniques of harnessing daylight have contrasted with the views of experts indicating the lack of these techniques in contemporary Iranian houses.

Summary of the Findings

In this study, by analyzing and evaluating the use of daylight in traditional dwellings as a complexes issue with multiple dimensions, fundamental findings have emerged. This process has brought up findings in terms of using daylight in traditional residences which can be extrapolated into modern dwellings in order to increase the use of daylight and enhance well-being. These include:

- Traditional houses have offered good techniques for using daylight which can be extrapolated into contemporary houses as an alternative to what is done today; however, it would be required to update the these techniques and to adapt them to the structural and functional changes of modern dwellings in order to be practical and useful.
- Occupants have preferred to use more daylight in their houses since firstly daylight has great impacts on their well-being. Secondly, the use of more daylight has reduced the consumption of electricity and decreased related expenses. Finally, providing daylight through windows and openings has connected users to outdoor world.
- Architects and experts have lamented that traditional houses have utilized daylight as their principal source of lighting but in modern dwellings, based on current legislations, the use of daylight was decreased and led to the significant reduction of well-being in contemporary houses.

6.1. Research Limitations

There were several limitations on the research study, and some issues have arisen during data collection and analysis phases. First, the major limitation for this research was the availability of reliable and valid sources about using daylight in Iranian traditional courtyards. Therefore, many sources were reviewed and among them the most valid ones were selected as reference. Furthermore, some selected references were only available as printed copy in Iran. Thus, these documents were scanned and sent to the researcher via email by the research collaborator in Iran. Access to the printed copy sources was as one of the difficulties of this research. Definitely, having access to more references can have provided the researcher with more data to establish, confirm, and support in more detail the research questions.

Second, since the research was done from Montreal, accessing Iranian experts, explaining to the participants the context of research and organizing the interviews was a challenge. Originally interviews were planned, but these were replaced by the questionnaires, to be able to reach participants easily. Conducting interviews with experts has provided an opportunity to go further in detail. Moreover, distributing the questionnaires among experts has necessitated cooperating with an Iranian university as a facilitator in the process. This step has required many official correspondence and permissions in both countries. This step was one of principal difficulties in this research as it was very time-consuming.

Third, the process of selecting traditional houses is another limitation of this research. Since the research was conducted in Montreal and visiting the historic site of this research in person and selecting the traditional cases was not easily possible, the study cases were chosen among 19 historic houses which were registered by the cultural heritage organization of Iran. These 19 registered houses were mostly the houses of the upper echelons of the social scale. Hence, this issue has had an impact on the validity of generalizing the shared techniques of using daylight that were extracted from the 3 study cases of this research to all courtyard houses. Surely, studying more cases from separate echelons of social scale in this historic site will bring more valid data and consequently increase the validity of this research.

Fourth, the lack of computer-generated three-dimensional models of the case study houses is the next limitation. Since the research was conducted in Montreal and visiting the cases in person was not possible, the computer tri-dimensional models were made as accurately as possible in comparing with the real counterparts, based on information available at the time. Therefore, all required dimensions were provided through the architectural drawings, images and information drawn from the literature.

Furthermore, some challenges have arisen in this phase: firstly, since the drawings and the images were in jpeg format, accurate two dimensional drawings required for tri-dimensional modeling were made and then these drawings were used for modeling. Secondly, considering the structural complexity of models in terms of geometry includes domes and arcs, the process of modeling was complex. Hence, the lack of already made tri-dimensional models and accurate two dimensional drawings besides the complexity of modeling cases has caused to choose the 3 houses for study that revealed the most information about benefiting from daylight both exterior and interior.

Moreover, the main difficulty of this research emerged was the lack of adequate information about the selected daylight simulation software (Autodesk Ecotect) including understanding the program and how best to extrapolate data necessary the daylight modelling. Since the models were quite complex, the analyses of computer daylight simulations has taken extensive time. Similarly, the final output for the analysis has required a large amount of time. Hence, in case of any change or error an additional time was added for doing corrections.

Finally, Autodesk® Ecotect®, which was selected for conducting daylight simulation through the study cases, has represented a 'static' analysis of daylight. In other words, daylight levels in the study cases was calculated in the worst-case design scenario based on an overcast sky distribution in mid-winter and the local climate has not be taken into account. However, some other daylight simulation software provides dynamic, climate-based daylight analysis which can presents more accurate data.

6.2. Research Contributions

The results of this research can contribute to some areas as follows: in residential design, designers may become more aware of the importance of using daylight and consequently put more emphasis on using daylight in dwellings. In addition, they may apply the findings of this research in their future designs and maximize the use of daylight to enhance well-being.

This study may influence on residential building design by bringing out a new approach for improving well-being of the occupants throughout considering and optimizing the use of daylight in modern dwellings. Thus, occupants may be contributed from the result of this research. Indeed, occupants' well-being will be improved by increasing the use of daylight in dwellings. Besides, the occupants can save noticeable money by reducing the cost of energy and also health care issues.

Planners and authorities may take advantage of the results of this research in urbanism and urban design. By considering the advantage of using daylight, they may consider legislation that accounts for the ways that daylight might be better harnessed using Iranian construction methods in residential design.

Finally, in academia, the results of this research contribute to researchers and professors enthusiastic in architecture or traditional architecture, Iranian architecture or traditional Iranian architecture and the use of daylight in Iranian dwellings from the past up to now. Moreover, all students who follow related fields and are interested in studying the wisdom of the past architecture may benefit from this research which has provided an approach for studying and analyzing the past architecture.

6.3. Future considerations for Research

By considering correlation between the pattern of using daylight in Iranian traditional dwellings and the structural and functional patterns of these houses and regarding the different structural and functional patterns of modern houses than the structural and functional patterns of traditional dwellings, future issues that can arise include:

- How to extrapolate the traditional techniques of using daylight into Iranian modern houses?

- How to respect traditional techniques of using daylight within the realities of cheaper contemporary building methods and laws?
- What is the value of vernacular architecture in Iran in terms of optimizing the use of daylight and enhance well-being in Iran?
- What is the value of vernacular architecture in terms of the more modern approaches favoured in Iran today?
- What is the value of daylight in contemporary Iranian architecture?

Indeed, this research can be used as a study model for dealing with similar problems in many developing countries. In other words, however the research has targeted a part of current problems in a country but provided and shaped a thinking model which can be used to study and analyze vernacular architecture in any country to extrapolate its positive aspects into modern architecture. Hence, the proposed approach of this research project may be used as a model to deal with modern similar issues. Finally, this research contributes to defining a new perspective on using daylight in modern dwellings through learning from traditional residential architecture.

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Appendixes

Appendix I: Ethical Certification

No de certificat (1)
CPER-13-040-D

Université de Montréal

Comité plurifacultaire d'éthique de la recherche (CPÉR)
Facultés de l'aménagement, de droit, de musique, des sciences de l'éducation et de théologie et de sciences des religions

CERTIFICAT D'ÉTHIQUE

Le *Comité plurifacultaire d'éthique de la recherche* (CPÉR), selon les procédures en vigueur et en vertu des documents qui lui ont été fournis, a examiné le projet de recherche suivant et conclu qu'il respecte les règles d'éthique énoncées dans la *Politique sur la recherche avec des êtres humains* de l'Université de Montréal.

Titre du projet	**Benefiting from natural light in Iran's today dwelling regarding Iranian traditional courtyard house**
Étudiant requérant	**Ramin RAHIM-ZADEH-NASKHI** [redacted] Candidat à la maîtrise en design et complexité Faculté d'aménagement Université de Montréal
Direction	Tiiu Vaïkla-Poldma Professeure titulaire École de design industriel - Faculté d'aménagement Université de Montréal
Financement	Non financé

MODALITÉS D'APPLICATION
Tout changement anticipé au protocole de recherche doit être communiqué au CPÉR qui en évaluera l'impact au chapitre de l'éthique.

Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CPÉR.
Selon les règles universitaires en vigueur, un **suivi annuel** est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CPÉR.

[redacted]

Pierre Lapointe, président
Comité plurifacultaire d'éthique de la recherche
Université de Montréal

28 / 06 / 2013
Date de délivrance

01 / 07 / 2014
Date de fin de validité

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Appendix II: Consent Form

Université de Montréal

Faculty of Environmental Design
M.Sc. Environmental Design, Design and complexity

A) CONSENT FORM FOR PARTICIPATION IN
RESEARCH-PROJECT LABORATORY'S QUESTIONNAIRE

Project title: NATURAL LIGHTENING A DWELLING: a case study of daylighting techniques in traditional courtyards versus contemporary apartments in Iran

Researcher: Ramin Rahim-Zadeh-Naskhi, Master's candidate of environmental design, Design and complexity option, Faculté de l'aménagement, Université de Montréal, Canada

Research supervisor: Dr. Tiiu Poldma, Full professor, School of industrial design, Interior design program, Faculté de l'aménagement, Université de Montréal, Canada

A.1) PARTICIPANTS' INFORMATION

1. Research-project laboratory objectives
Through this questionnaire, we want to know your personal views about use of daylighting in design process of an Iranian dwelling, the current problems and potential ways out. Furthermore, we want to know your opinions about the Iranian traditional courtyards and their success and failure in benefiting from the natural lighting; and plus advantages and disadvantages of reusing their achievements in the future dwellings.

2. Participation in the Research-project laboratory
Your participation in this research consists of answering to 10 questions of this questionnaire. These questions can be answered whenever and wherever you would prefer during 5 days. This questionnaire will focus on your personal views about using the natural lighting in design process of an Iranian dwelling. The questions should be answered in separate sheets and attached to this forms with other required documents such as your CV.

3. Confidentiality
The information you provide will remain confidential. Each research participant will be assigned by a number and only the principal researcher and/or the authorized person for this purpose will have the list of participants and the numbers that have been assigned to them. In addition, the information will be scanned and saved in a locked folder located on a portable external hard disk and the original copies will be destroyed. The external hard drive will be kept at the office of Dr. Tiiu Poldma, the research's supervisor and full professor at the Université de Montréal, Canada. The information that can identify you in one way or another will not be published. This personal information will be destroyed seven years after the end of the project. Only data that does not identify you will be kept after this date, the time required for their use.

4. Advantages and disadvantages
By participating in this research, you do not run any risk or particular disadvantages and you could contribute to the knowledge advancement and strategy improvement of benefiting from the natural lighting in the future dwelling. Your participation in the research will give us the opportunity to obtain a better understanding about the problems of using of natural lighting in designing the today dwelling and furthermore, the potential of the traditional courtyards' strategies to be considered as a solution. This information helps us to conduct our research project more appropriately.

Université de Montréal

Faculty of Environmental Design
M.Sc. Environmental Design, Design and complexity

5. Right to withdrawal
Your participation is completely voluntary. Therefore, you are free to withdraw at any time by simple verbal notice, without prejudice and without having to justify your decision. If you decide to withdraw from the research, you may contact the researcher at the phone number or the email address listed below. If you withdraw from the research, the information that has been collected will be destroyed at the time of withdrawal.

6. Compensation
Participants will receive no financial compensation for their participation in the research.

7. Dissemination of results
The final results will be transmitted to Université de Montréal describing the general conclusions of this questionnaire when the analyses will be completed. The final results might be sent either through email or via mail to the participants who make the request, by writing your contact information in the related section in below. Your contact information will be kept strictly confidential and only will be used for transmission of the final results.

A.2) CONSENT
I declare having read the information above, having obtained answers to my questions about my participation in the research and understand the purpose, nature, benefits, risks and limitations of this research. After thinking and a reasonable time, I freely consent to participate in this research. I know that I can withdraw at any time without prejudice, upon verbal notice and without having to justify my decision.

Signature: ______________________ Date: ______________________

Last name: ______________________ First name: ______________________

If you would like to receive a report explaining the final results of this survey, indicate your contact information and the way you prefer to receive that in below please.

By email ☐ By mail ☐

Email address: ______________________

Postal address: ______________________

I declare that I explained the purpose, nature, benefits, risks and limitations of the study and answered to the best of my knowledge the questions.

Researcher's signature: ______________________ Date: ______________________

Last name: ______________________ First name: ______________________

For any concerning question or to withdraw from the project, you can contact Ramin Rahim-Zadeh-Naskhi, Master's candidate and researcher, by telephone number [redacted] or via email address: [redacted]

Any complaint about your participation in this research may be addressed to the ombudsman of Université de Montréal, by telephone number at: +1 (514) 343-2100 or by the following email address: ombudsman@umontreal.ca **(ombudsman accepts collect calls).**

A copy of the information form and signed consent must be given to the participant.

Appendix III: Consent Form in Persian

Université de Montréal

دانشکده طراحی محیطی

کارشناسی ارشد طراحی محیطی، گرایش طراحی و پیچیدگی

الف) رضایت نامه برای شرکت در پرسشنامه ی آزمایشگاه تحقیق -پروژه

عنوان پروژه: روشنایی طبیعی در خانه: یک مطالعه موردی از تکنیک های بهره وری از روشنایی روز در حیاط سنتی در مقایسه با آپارتمان معاصر در ایران

پژوهشگر: رامین رحیم زاده نسخی، دانشجوی کارشناسی ارشد در طراحی محیطی، گرایش طراحی و پیچیدگی، دانشکده طراحی محیطی، دانشگاه مونترال، کانادا

استاد راهنما: دکتر تی یو پولدما، استاد تمام، مدرسه طراحی صنعتی، برنامه طراحی داخلی، دانشکده طراحی محیطی، دانشگاه مونترال، کانادا

الف.1) اطلاعات شرکت کنندگان

1. اهداف آزمایشگاه تحقیق -پروژه

از طریق این پرسشنامه، می خواهیم نظر شخصی شما را پیرامون استفاده از روشنایی روز در فرایند طراحی یک خانه ی ایرانی، مشکلات موجود و راههای برونرفت بالقوه بدانیم. علاوه بر این، می خواهیم دیدگاه شما را در مورد حیاط های سنتی ایرانی و موفقیت و شکست آنها در بهره گیری از نور طبیعی و بعلاوه مزایای و معایب استفاده از دستاوردهای آنها را در خانه های آینده بدانیم

2. مشارکت در آزمایشگاه تحقیق -پروژه

مشارکت شما در این پژوهش عبارت از پاسخگویی به 10 سوال این پرسشنامه است. این سوال ها میتوانند در هر زمان و هر کجا که شما ترجیح می دهید در طول 5 روز را پاسخ داده شوند. این پرسشنامه بر روی نظرات شخصی شما در مورد استفاده از نور طبیعی در فرایند طراحی مسکن ایرانی تمرکز می کنند. سوالات باید در ورق جداگانه پاسخ داده و با سایر مدارک مورد نیاز از قبیل رزومه شما به این فرم پیوست شود.

3. محرمانه ماندن اطلاعات

اطلاعات ارائه شده محرمانه باقی خواهد ماند. به هر شرکت کننده در پژوهش یک شماره ی اختصاص داده خواهد شد و تنها پژوهشگراصلی و/ یا شخص مجاز برای این منظور لیستی از شرکت کنندگان و اعدادی که به آنها اختصاص داده شده اند را خواهد داشت. علاوه بر این، اطلاعات اسکن خواهد شد و دریک پوشه قفل شده بر روی یک سخت دیسک خارجی قابل حمل ذخیره و نسخه اصلی نابود خواهد شد. هارد درایو خارجی در دفتر دکتر تی یو پولدما، استاد راهنمای تحقیق و استاد تمام در دانشگاه مونترال کانادا، نگهداری می شود. اطلاعاتی که به هر شکلی می تواند هویت شما را مشخص کند منتشر نخواهد شد. این اطلاعات شخصی هفت سال پس از پایان پروژه نابود خواهد شد. فقط داده هایی را هویت شما را مشخص نخواهد کرد بعد از این تاریخ نگهداری می شود، زمان مورد نیاز برای استفاده از آنها.

4. مزایا و معایب

با شرکت در این پژوهش، هیچگونه خطر و ضرر خاصی متوجه شما نخواهد بود و شما می توانید به پیشرفت دانش و بهبود استراتژی استفاده از روشنایی طبیعی در مسکن آینده کمک کنید. مشارکت شما در این پژوهش به ما فرصت به دست آوردن درک بهتر میدهد در مورد مشکلات استفاده از نور طبیعی در طراحی مسکن امروز و علاوه بر آن، پتانسیل راهکارهای حیاط مرکزهای سنتی برای در نظر گرفته شدن به عنوان یک راه حل. این اطلاعات به ما کمک می کند تا پروژه تحقیقاتی ما به شکل درست تری انجام پذیرد.

5. حق انصراف

مشارکت شما کاملا داوطلبانه است. بنابراین، شما آزاد هستید در هر زمان با اعلان کلامی ساده، بدون پیش داوری و بدون نیاز به توجیه تصمیم خود انصراف دهید. اگر تصمیم به انصراف از پژوهش گرفتید ، می توانید با محقق با شماره تلفن ذکر شده در زیر تماس بگیرید. اگر از این تحقیق انصراف دهید، اطلاعات جمع آوری شده در زمان انصراف نابود خواهد شد.

فرم رضایت نامه و پرسشنامه ی آزمایشگاه تحقیق -پروژه - رامین رحیم زاده نسخی - نسخه 1.1 - 1392/03/31 - 1/3

دانشکده طراحی محیطی

کارشناسی ارشد طراحی محیطی، گرایش طراحی و پیچیدگی

6. حقوق و مزایا

شرکت کنندگان هیچ پاداش مالی برای مشارکت آنها در این تحقیق دریافت نخواهند کرد.

7. انتشار نتایج

یک گزارش به دانشگاه مونترال درتوصیف نتیجه کلی از این پژوهش، زمانی که تجزیه و تحلیل تکمیل خواهد شد منتقل می شود. نتایج نهایی یا از طریق ایمیل و یا از طریق پست، برای شرکت کنندگانی که با نوشتن اطلاعات تماس خود در بخش مربوطه در زیر درخواست میکنند فرستاده خواهد شد. اطلاعات تماس شما به شکل شدیدا محرمانه نگه داشته خواهد شد و فقط برای انتقال نتایج نهایی استفاده می شود.

الف. 2) رضایت نامه

من اعلام می کنم که اطلاعات فوق را خوانده، پاسخ سوالات من در مورد شرکت من در این تحقیق به دست آمده و هدف آن، طبیعت، منافع، خطرات و محدودیت های این پژوهش را درک کرده ام. پس از تفکر و یک مدت زمان معقول، من آزادانه برای شرکت در این تحقیق رضایت میدهم. من می دانم که من می توانم در هر زمان بدون تعصب، پس از اعلان شفاهی و بدون نیاز به توجیه تصمیم خود انصراف دهم.

تاریخ: ____________ امضا: ____________

نام: ____________ نام خانوادگی: ____________

اگر شما می خواهید یک گزارش در توضیح نتایج نهایی از انجام این پرسشنامه دریافت کنید، لطفاً اطلاعات تماس خود و شیوه ای که برای دریافت این اطلاعات ترجیح می دهید را در زیر درج نمایید.

توسط پست الکترونیکی ☐ توسط پست ☐

آدرس پست الکترونیکی ____________

آدرس پستی ____________

من اعلام می کنم که هدف، طبیعت، منافع، خطرات و محدودیت های این مطالعه توضیح داده و به بهترین شکل به سوالات پاسخ داده ام.

تاریخ: ____________ امضا: ____________

نام: ____________ نام خانوادگی: ____________

برای هر گونه سوال مرتبط و یا انصراف از پروژه، شما می توانید با رامین رحیم زاده نسخی، پژوهشگر و دانشجوی ارشد تماس بگیرید، از طریق شماره تلفن: 2055-770 (514) 1+ و یا آدرس پست الکترونیک: [redacted]

هر گونه شکایت در مورد مشارکت در این پژوهش میتواند به بازرس دانشگاه مونترال ارجاع داده شود، شماره تلفن 2100-343 (514) 1+ یا پست الکترونیک: [redacted] **(بازرس هزینه تماس را قبول میکند).**

یک کپی از فرم اطلاعات و رضایت نامه ی امضا شده باید به شرکت کنندگان داده شود.

Appendix IV: Questionnaire

Université de Montréal

Faculty of Environmental Design
M.Sc. Environmental Design, Design and complexity

B) QUESTIONNAIRE

● ***PLEASE ATTACH YOUR ANSWERS AND YOUR CV TO THIS QUESTIONNAIRE***

B.1) QUESTIONNAIRE DESCRIPTION
The questionnaire contains 3 parts: in the first part, we try to find an understanding about your personal experience in confronting with natural lighting in design process of a dwelling. In the second part, we want to find out your opinion about the current problems in designing of the residential building relating to the natural lighting and what you suggest as a way out. Finally, in the last part of this survey, we direct the questions toward your viewpoint about the traditional houses and rate of their success and failure in benefiting from the natural lighting, furthermore advantages and disadvantages of reusing their achievements in today residential buildings for benefiting from the natural lighting.

B.2) QUESTIONS
Part 1) Personal experiences
This part is about your personal experiences concerning benefiting from natural lighting in designing of the residential buildings. In each question either your answer is positive or not, please explain your reasons.

1. What is the position of the natural lighting in your design for a residential building?
2. What is the priority that you consider for the natural lighting in designing a dwelling?
3. With regard to using natural lighting in your projects, could you mention to weaknesses and strengths in some cases? *Please attach related documents and photos.*

Part 2) Current situation of dwelling
The second part is concentrated on the current situation of residential buildings in Iran in terms of using natural lighting.

1. Could you mention to limitations that you may face in Iran for using the natural lighting in designing of a today dwelling in terms of building codes and cultural norms and etc.?
2. By considering the mentioned limitations, what are your suggested ways for benefiting from natural lighting in today residential building?
3. What are the current problems' ways out for using natural lighting in today dwellings?

Part 3) Traditional residential buildings
The third part is focused on your approach relative to the traditional residential buildings. This section is also particularly about your knowledge relating to Iranian dwellings in the past.

1. How much knowledge do you have about Iranian traditional residence?
2. How much successful do you consider traditional residential buildings for methods that they used for benefiting from natural lighting and could these methods be used in today residential architecture for solving the mentioned problems?
3. As an Iranian contemporary architect, do you consider the traditional methods for using the natural lighting as one of the options on the table for solving the current problems?

4. Could you mention to some examples among today designed residential building that using the natural lighting was done by regarding the traditional methods? Please criticize some of these examples?

Research-Project Laboratory – Ramin Rahim-Zadeh-Naskhi – version 1.01 – Date 30/06/2013 – Page 3/3

Appendix V: Questionnaire in Persian

Université de Montréal

دانشکده طراحی محیطی

کارشناسی ارشد طراحی محیطی، گرایش طراحی و پیچیدگی

ب) پرسشنامه ی آزمایشگاه تحقیق -پروژه

- ***لطفا پاسخ ها و رزومه خود را به این پرسشنامه پیوست نماید.***

ب.1)توضیحات درباره پرسشنامه

این پرسشنامه شامل 3 بخش است: در قسمت اول، سعی می کنیم در مورد تجربه شخصی شما در مواجهه با نور طبیعی در فرایند طراحی خانه آگاهی پیدا کنیم.در قسمت دوم، می خواهیم نظر شما را در مورد مشکلات موجود در طراحی ساختمان های مسکونی در رابطه با روشنایی طبیعی بدانیم و آنچه شما آن را به عنوان راه برون رفت پیشنهاد میدهید. در نهایت، در آخرین قسمت از این پرسشنامه، سوالات را به سمت نقطه نظر شما پیرامون خانه های سنتی و میزان موفقیت و شکست آنها در بهره گیری از نور طبیعی هدایت میکنیم، بعلاوه مزایا و معایب استفاده مجدد از دستاوردهای آنها در ساختمان های مسکونی امروز در راستای بهره گیری از روشنایی طبیعی.

ب.2) سوالات

قسمت اول) تجارب شخصی:

این قسمت در مورد تجربیات شخصی شما در رابطه با بهره گیری از نور طبیعی در طراحی ساختمان های مسکونی می باشد. در هر سوال چه جواب شما مثبت است چه منفی، لطفاً دلایل خود را توضیح دهید.

1. آیا نور طبیعی یکی از عوامل تاثیرگذار در طراحی شما برای یک ساختمان مسکونی بشمار می آید؟
2. اولویت استفاده از نور طبیعی در طراحی یک خانه از نظر شما چیست؟
3. رویکرد شما نسبت به نور طبیعی چه نقاط قوت و ضعفی در پروژه های شما ایجاد کرده است؟ *لطفا اسناد و تصاویر مربوط را ضمیمه کنید.*

قسمت دوم) وضعیت کنونی مسکن:

بخش دوم بر وضعیت فعلی ساختمان های مسکونی در ایران از لحاظ استفاده از روشنایی طبیعی متمرکز شده است.

1. می توانید به محدودیت های که شما ممکن است برای استفاده از روشنایی طبیعی در طراحی یک خانه امروزی در ایران از لحاظ کدهای ساختمانی، معیارهای فرهنگی و غیره مواجه شوید اشاره کنید؟
2. با توجه به محدودیت های ذکر شده، راههای برون رفت پیشنهادی شما برای بهره گیری از نور طبیعی در ساختمان های مسکونی امروز چه هستند؟

قسمت سوم) ساختمان های سنتی مسکونی:

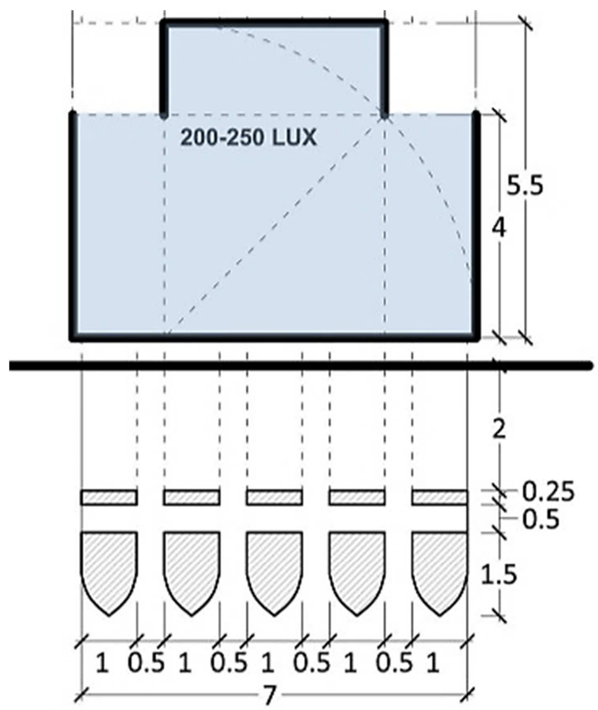
قسمت سوم بر روی رویکرد شما نسبت به ساختمان های مسکونی سنتی متمرکز شده است. این بخش بطور خاص در مورد شناخت شما نسبت به مسکن ایرانی در گذشته است.

1. در مورد معماری مسکونی سنتی ایران چه میزان شناخت دارید؟
2. چه میزان ساختمان های مسکونی سنتی را از نظر شیوه هایی که برای بهره گیری از نور طبیعی بکار برده اند موفق میدانید؟
3. آیا این روشها میتوانند در معماری مسکونی امروز به عنوان یکی از گزینه های روی میز برای حل مشکلات فعلی در نظر گرفته شوند؟

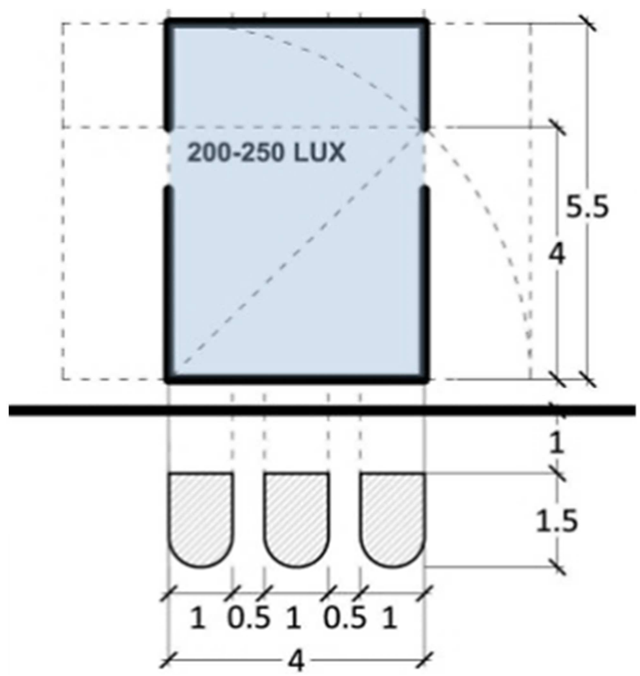
4. می توانید چند نمونه در میان ساختمان های مسکونی امروز ذکر نمایید که استفاده از نور طبیعی با توجه به روش های سنتی انجام شده است؟ لطفا برخی از این مثال ها را نقد کنید.

فرم رضایت نامه و پرسشنامه ی آزمایشگاه تحقیق -پروژه - رامین رحیم زاده نسخی - نسخه 1.1 - 1392/03/31 - 3/3

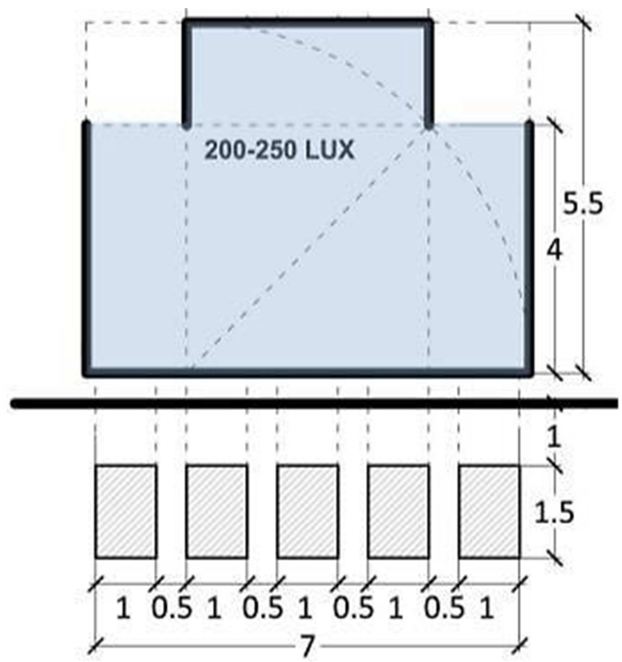
Appendix VI: Analysis of Windows Characteristic

COURTYARD FAÇADE	CASE NO. 1
	
space dimensions	length: 7 m depth: 5.5 m height: 6 m
glazing type	single glazing
windows layout	close continuous punched pattern (0.5 meter break between windows)
window dimensions (typical)	width: 1 m height: 1.5 m 5 windows
window-head height	4.25 m

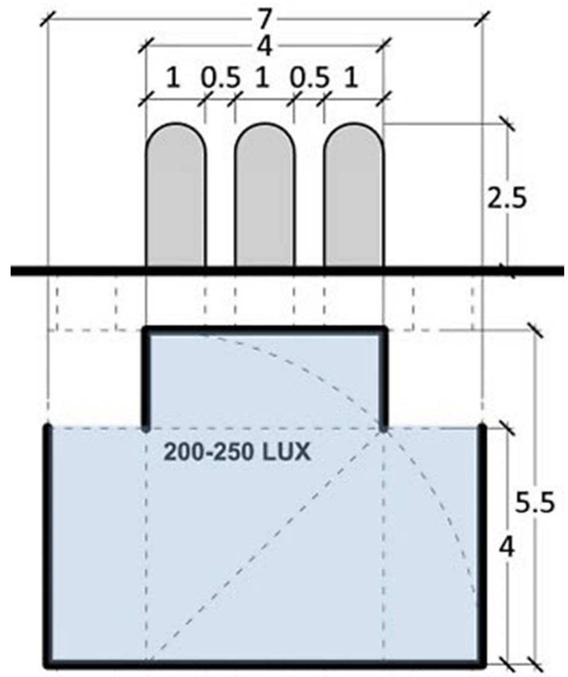
Windows characteristics on courtyard façade, case no. 1. Created by author

COURTYARD FAÇADE	CASE NO. 2
	
space dimensions	length: 4 m depth: 5.5 m height: 4 m
glazing type	single glazing
windows layout	close continuous punched pattern (0.5 meter break between windows)
window dimensions (typical)	width: 1 m height: 1.5 m 3 windows
window-head height	2.5 m

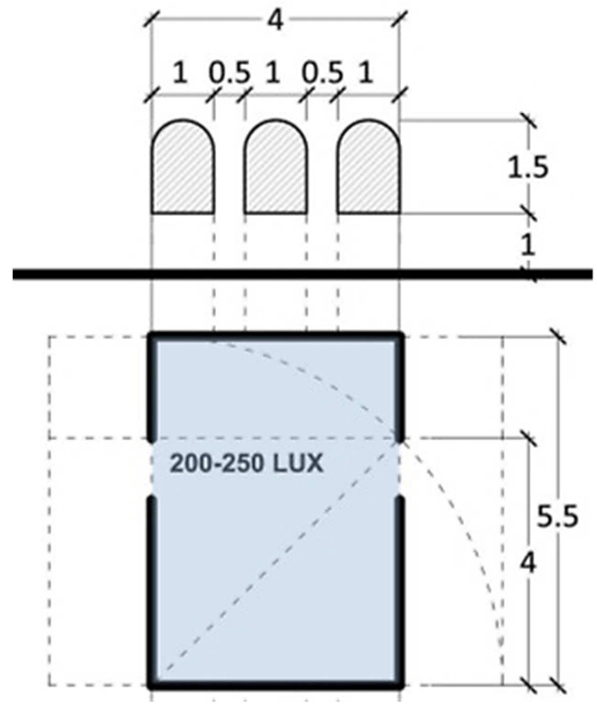
Windows characteristics on courtyard façade, case no. 2. Created by author

<table>
<tr><td rowspan="2">COURTYARD FAÇADE</td><td>CASE NO. 3</td></tr>
<tr><td>
</td></tr>
<tr><td>space dimensions</td><td>length: 7 m
depth: 5.5 m
height: 7 m</td></tr>
<tr><td>glazing type</td><td>single glazing</td></tr>
<tr><td>windows layout</td><td>close continuous punched pattern (0.5 meter break between windows)</td></tr>
<tr><td>window dimensions (typical)</td><td>width: 1 m
height: 1.5 m
5 windows</td></tr>
<tr><td>window-head height</td><td>2.5 m</td></tr>
</table>

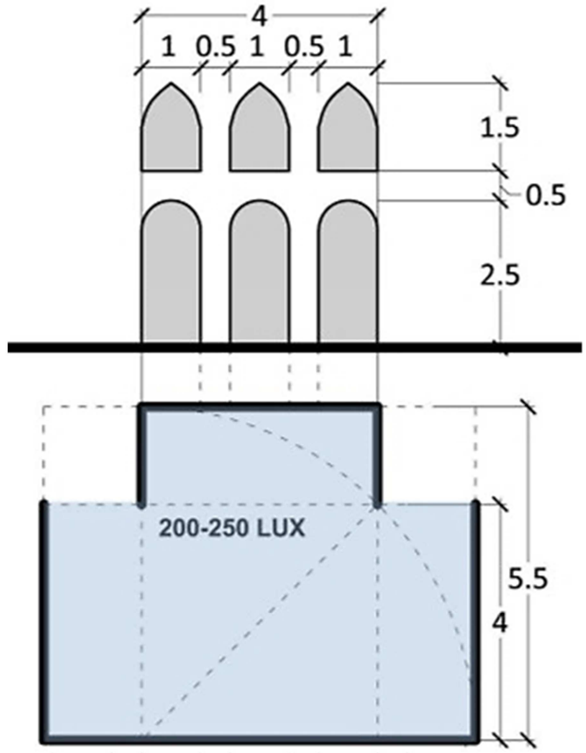
Windows characteristics on courtyard façade, case no. 3. Created by author

BACKYARD FAÇADE	CASE NO. 1
	
space dimensions	length: 7 m depth: 5.5 m height: 6 m
glazing type	Lattice
windows layout	close continuous punched pattern (0.5 meter break between windows)
window dimensions (typical)	width: 1 m height: 2.5 m 3 windows
window-head height	2.5 m

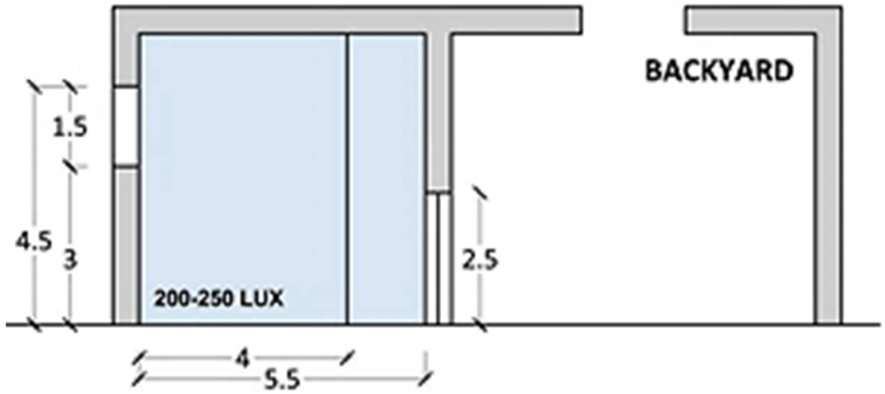
Windows characteristics on backyard façade, case no. 1. Created by author

	CASE NO. 2
BACKYARD FAÇADE	
space dimensions	length: 4 m depth: 5.5 m height: 4 m
glazing type	single glazing
windows layout	close continuous punched pattern (0.5 meter break between windows)
window dimensions (typical)	width: 1 m height: 1.5 m 3 windows
window-head height	2.5 m

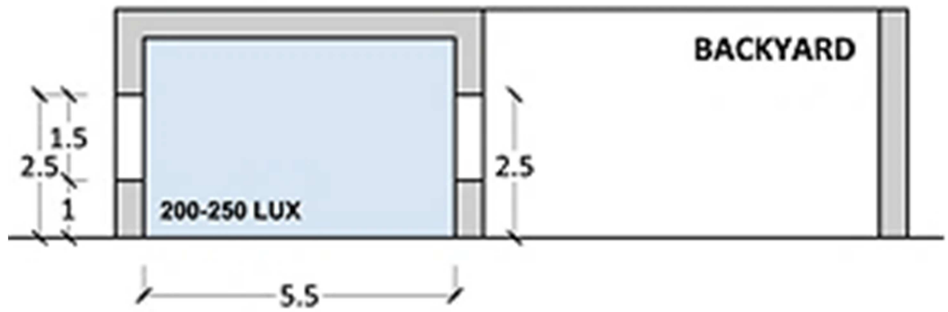
Windows characteristics on backyard façade, case no. 2. Created by author

BACKYARD FAÇADE	CASE NO. 3
	
space dimensions	length: 7 m depth: 5.5 m height: 7 m
glazing type	Lattice
windows layout	close continuous punched pattern (0.5 meter break between windows)
window dimensions (typical)	width: 1 m height: 2.5 and 1.5 m 3 windows
window-head height	4.5 m

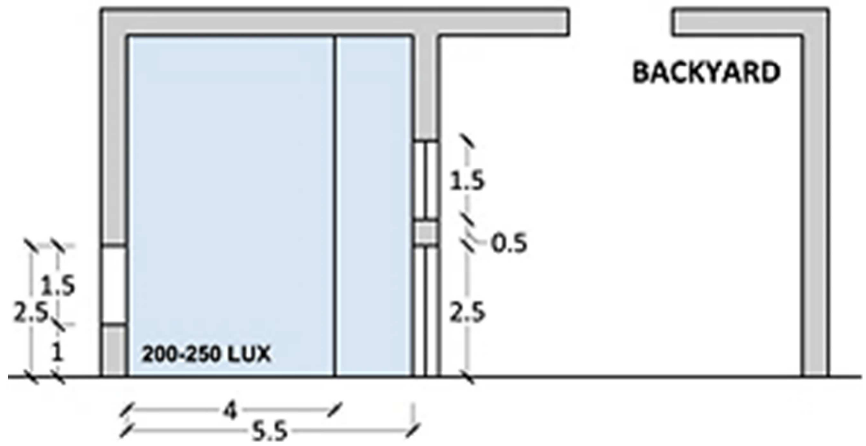
Windows characteristics on backyard façade, case no. 3. Created by author

SECTION	CASE NO. 1	
		
space dimensions	length: 7 m depth: 5.5 m height: 6 m	
courtyard façade	window dimensions (typical)	width: 1 m height: 1.5 m 5 windows
	window head height: 4.5 m	single glazing
	close continuous punched pattern (0.5 meter break between windows)	
Backyard façade	window dimensions (typical)	width: 1 m height: 2.5 m 3 windows
	window head height: 2.5 m	lattice
	close continuous punched pattern (0.5 meter break between windows)	

Analysis of windows characteristic in section, case no. 1. Created by author

<table>
<tr><td rowspan="2">SECTION</td><td colspan="2">CASE NO. 2</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>space dimensions</td><td colspan="2">length: 4 m
depth: 5.5 m
height: 4 m</td></tr>
<tr><td rowspan="3">courtyard façade</td><td>window dimensions (typical)</td><td>width: 1 m
height: 1.5 m
3 windows</td></tr>
<tr><td>window head height: 2.5 m</td><td>single glazing</td></tr>
<tr><td colspan="2">close continuous punched pattern (0.5 meter break between windows)</td></tr>
<tr><td rowspan="3">Backyard façade</td><td>window dimensions (typical)</td><td>width: 1 m
height: 1.5 m
3 windows</td></tr>
<tr><td>window head height: 2.5 m</td><td>lattice</td></tr>
<tr><td colspan="2">close continuous punched pattern (0.5 meter break between windows)</td></tr>
</table>

Analysis of windows characteristic in section, case no. 2. Created by author

<table>
<tr><td rowspan="2">SECTION</td><td colspan="2">CASE NO. 2</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td>space dimensions</td><td colspan="2">length: 7 m
depth: 5.5 m
height: 7 m</td></tr>
<tr><td rowspan="3">courtyard façade</td><td>window dimensions (typical)</td><td>width: 1 m
height: 1.5 m
5 windows</td></tr>
<tr><td>window head height: 2.5 m</td><td>single glazing</td></tr>
<tr><td colspan="2">close continuous punched pattern (0.5 meter break between windows)</td></tr>
<tr><td rowspan="3">Backyard façade</td><td>window dimensions (typical)</td><td>width: 1 m
height: 2.5 and 1.5 m
3 windows</td></tr>
<tr><td>window head height: 4.5 m</td><td>lattice</td></tr>
<tr><td colspan="2">close continuous punched pattern (0.5 meter break between windows)</td></tr>
</table>

Analysis of windows characteristic in section, case no. 3. Created by author