Application of Transparency to Increase Day-Lighting Level of Interior Spaces of Dwellings in Tehran - A Lesson from the Past

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Abstract: - The amount of day lighting through internal layers of apartments of the city of Tehran has significantly decreased, which is because of lack of space and windows area. This lack of day light has created dark spaces in central parts of the plan that is because of the improper access to the natural light which the main problem that this research is studying. However through all historic durations there is a rich architectural heritage without which the lighting problems in contemporary apartments could not be solved. The objective of this paper is to gain lighting strategies to increase day lighting and luminance level into contemporary houses. Using transparent elements and creating transparent spaces between public and private areas in order to pass the day light to the internal layers can be one of the solutions. The method of this research is a deep analysis on Traditional architecture of Iran and day-lighting strategies that were successfully used. After that by analyzing contemporary architecture of Tehran, current problems will be shown and discussed. Comparing traditional architecture of Iran with the contemporary one and applying new strategies, which is in concord with Iran’s culture and climate, will be the main outcome of this study.

Key-Words: Day lighting, Dwelling, Iranian architecture, Transparency, Advanced daylight system, high-rise apartments

1 Introduction
Natural light is the primary source of lighting in a building, due to the lower costs and the permanent source which it has. It is suggested for buildings to be designed in a way to use as much day light as they can, and create a little heat and electricity waste. The most effective role of daylight strategies and the way it enters the building is through window and different forms of apertures. The design of windows is in constant development, both in the form of the aperture through which the daylight comes and in the nature of glass or transparent material permitting the light to enter. According to Philips, “Windows do more than let in light and are often associated with solar shielding and ventilation” [9]. On the other hand, there are some cases that windows are not used, and instead of that, wide glassy areas on the façade are working to bring the light in. Transparency in new buildings besides creating bright spaces has created a direct connection between inside and outside of an architectural project. For instance during a snowy day, standing beside a large piece of glass which overlooks the big white garden, makes a paradox since the glass has just stopped the air for transmit inside while the view is in continuation.

Traditional architecture of Iran has been a subject scrutiny for decades, and by such researches many mysterious tricks are discovered with which architects are able to create meaningful spaces. Besides its functional aspect, day lighting was important in traditional architecture due to the spiritual and decorative aspect. Day lighting was that mixed with other elements of architecture that no one could separate or omit it [2]. In today’s architecture of Iran, through the years, natural lighting is missed and is no longer playing a key role in designing the apartments. Nowadays, natural lighting is just a source for brightening the space based on criterions. Bringing back the spirit of space through natural light in apartments of Iran, based on traditional architecture that is in concord with Iranian culture, is what people need nowadays. Through all documents from traditional architecture and so many evidences, traditional architecture was a human axis architecture that tried to supply every human’s need [11].

Although in contemporary architecture there have been too many outstanding projects that are based on
Iran’s culture or architecture, this paper tries to focus on interior parts that are left light-less, and it do not have enough spatial quality.

By analyzing different dwelling plans of contemporary architecture of Tehran city, it is comprehensive that there are too many problems that have caused the lack of day lighting inside the building. The improper orientation of the building toward sunlight, the shrinkage of window area and building area as well, are some of these problems. This research is formed based on creating a suitable living area for people in order to increase the family gatherings in the bright areas since people are more likely to gather in bright spaces. Unfortunately the lack of such spaces is felt in small apartments in the city of Tehran. The procedure of this study is first clarifying the problems of contemporary architecture of Iran from the aspect of day lighting. Secondly, the study is going to extract new elements for interior parts of the house from traditional architecture of Iran and of course use modern lighting methods as well. After that, applying new alternatives inside the dwelling plan, in order to pass the light to the inner layers, and separation of public and private areas without conflicting cultural aspects will be the next step.

2 Advantages of Natural Lighting

Architects have been using the daylight within buildings to create a specific atmosphere. For instance the shafts of light entering the south side of great cathedrals; or in smaller scale, the use of daylight in a dwelling area even from above provides this small area with brightness and brings happiness to interior parts of the space. “The impression of daylight is also important seen from windows which themselves admit no sunlight, but where the view of a sunlit landscape or buildings may be enjoyed. Whenever sunlight is available there is a strong desire to perceive it, and disappointment when it is unnecessarily excluded” [10].

Natural light is considered to be coming directly from the sun. The nature of light has been discussed for centuries. Life would be unthinkable without light. However, it is also true that light has been and always will be a fascinating and mysterious element. In the 17th century, Isaac Newton exposed his corpuscular theory of light. After several experiments with prisms, Newton reached the conclusion that white light was made from all the colors of the rainbow. His corpuscular theory explains that the light is made up of luminous “bodies or particles” which are spread in straight lines. These bodies can pass through transparent materials and are reflected by opaque materials [3]. According to Greg.D and Ander, day lighting has the potential to significantly improve life-cycle cost, increase user productivity, reduce emissions, and reduces operating costs:

• Improved Life-Cycle Cost: At an estimated incremental first cost increase of from $0.50 to $0.75 per square foot of occupied space for dimmable ballasts, fixtures and controls; day lighting has been shown to save from $0.05 to $0.20 per square foot annually [in 1997 $].

• Increased User Productivity: Daylight enlivens spaces and has been shown to increase user satisfaction and visual comfort leading to improved performance.

• Reduced Emissions: By reducing the need for electric consumption for lighting and cooling, the use of daylight reduces greenhouse gases and slows fossil fuel depletion.

• Reduced Operating Costs: Electric lighting accounts for 35 to 50 percent of the total electrical energy consumption in commercial buildings. By generating waste heat, lighting also adds to the loads imposed on a building’s mechanical cooling equipment. The energy savings from reduced electric lighting through the use of day lighting strategies can directly reduce building cooling energy usage an additional 10 to 20 percent. Consequently, for many institutional and commercial buildings, total energy costs can be reduced by as much as one third through the optimal integration of day lighting strategies [7].

By all these advantages, there are some disadvantages such as glare and heat gain, that architecture is clashing with. The improper orientation of building and directions of windows plus wide glassy windows all caused uncomfortable situation for users. Also in Iran, there have always been ethical and cultural issues in constructing buildings. Privacy is as important as having the view. As a result of providing this privacy though large glassy windows in Tehran, thick curtains on the window and lack of day light during the day is born. There are variegate day lighting strategies in today architecture that each of them can be useful for introducing sunlight into the building. However not all of them can be used in a dwelling apartment. For example a small dwelling apartment in second floor
of a five-story apartment, cannot use skylight or light well for brightening interior parts of the plan.

3 Lighting Design Strategies of Traditional Buildings in Iran
Buildings in traditional architecture of Iran were all based on special principles, which were not eliminating. All these buildings were built in order to fulfill people's requirements. That is why among principles of Iranian traditional architecture, to be in accordance with people’s need is a noticeable issue. Different spaces that people used in a city, public or private, had a special behavior toward natural lighting. It seems like they were such openings, inviting day lighting in to the space to create variegate spaces. In Bazaars, mosques, public bathhouses and other urban elements, these behaviors toward light are evident. In the following section, several public spaces and the way they welcomed light, as well as some private spaces will be discussed.

### 3.1 Employing of Lighting Strategies in Public Spaces
In traditional cities, bazaars were an important public space, which were mostly in central areas of the city. Most of the important buildings and political centers of the city were formed close to Bazaar. Besides the economical function, it was the most important part of the city and worked as such an axis. The masjid jame, i.e. the main mosque of the city was next to bazaar. In addition, the main public bathhouse of the city, which was used by the well-known people, was there as well. The architecture of this area was as significant as its function. Mosque was the most articulated practical architecture, which was the element of God’s house and the place for prayers. Natural light was used in these buildings as well. Although Bazaars and public bathhouses are roofed spaces, there are functional usages of them for passing the light and creating movement and rhythm. In table below, there are different openings of traditional architecture, which introduces the daylight from different apertures. (Fig 1)

<table>
<thead>
<tr>
<th>Space quality</th>
<th>Functions</th>
<th>Day light diagrams and figures</th>
<th>Daylight production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>Bazaar</td>
<td><img src="image" alt="Bazaar Diagram" /></td>
<td>Movement/Rhythm</td>
</tr>
<tr>
<td></td>
<td>Mosque</td>
<td><img src="image" alt="Mosque Diagram" /></td>
<td>Mysterious space/Indirect light</td>
</tr>
<tr>
<td></td>
<td>Public bath-house</td>
<td><img src="image" alt="Public Bathhouse Diagram" /></td>
<td>Ventilation/Daylight and privacy</td>
</tr>
</tbody>
</table>

Fig 1 different day light components in traditional public buildings of Iran, which shows how much light they brought into the space and what was the production of this lighting

### 3.2 Employing Daylight Strategies in Private Spaces
The spatial characteristics of traditional Iranian houses reflect natural, geographical, and cultural needs. An important aspect of the traditional Iranian house is its adaptation to the harsh climate of the central parts of the country. Notable climatic problems are harsh sunlight and temperature in the
summer; diurnal fluctuations of temperature; low humidity; limited water supplies; and dusty, sandy winds. In areas of Iran with a hot and arid climate, special traditional designs found solutions to these problems. Therefore, the urban design and architectural style show evidence of these solutions [12]. The majorities of traditional houses are introverted, or look inwards. All the spaces were arranged around an open, rectangular courtyard that formed the link between different areas of the house. The arrangement follows certain geometrical rules.

3.2.1 Spatial Arrangement
The spatial order was collecting different spaces after each other because of two reasons. First is passing the light with a specific sequence that was prepared in a way to keep the privacy of the building. After passing the courtyard as an open space, there are usually semi-open/semi-closed spaces. These spaces were also semi-public/semi-private that were suitable spaces for family gatherings that had the potential to be expanded to each other. These spaces were unrestricted to open spaces and blocked were by a closed space. That is why these areas are also called covered areas. Closed spaces are for rooms and private areas for individuals. Closed spaces are closed from three sides and open from one side, which is in relation with open or covered area. Installation of transparent elements, porous walls and other light passing elements helps these areas to reach natural light and get some portion of it. (Fig 2 & 3)

![The outline of a traditional dwelling space, formed around a rectangular courtyard](image1)

<table>
<thead>
<tr>
<th>Covered area</th>
<th>Closed area</th>
<th>Open area</th>
</tr>
</thead>
</table>

Fig 2, typology of spatial arrangement in traditional architecture of Iran

![Fig 3, the analyzing of two steps for bringing light in to deeper layers of the plan, step 1 is spatial arrangement around open space; step 2 is using transparent façade and partitions in internal layers of building, in order to pass the light and avoid light obstruction into the space.](image2)
This architecture has been one of the sustainable architectures from both energetic and development aspects. In the illustration below one of the traditional houses of Iran is shown, in which different space qualities are completely introduced in order to access the light. (Fig 4)

**Fig 4**, different openings and day light strategies of traditional architecture of Iran through open, closed and covered elements

*Photos by Author*
In the above plan the indoor area of the house is divided into three degrees from lighting aspect. The first layer is the one, which is close to the openings and gets the day light from central courtyard directly. This space has the most potential to pass the light to the other spaces. The second layer, which is shown darker, is the area that gets the light from the first part and is using the natural day light as well. This space works as a mediate space for sharing the light. The third part is the one that gets the light from the intermediate area and from the small apertures on the ceiling. Because the light that is brightening this part is not as powerful as the part 1, due to its situation, it cannot get as much light as it needs; so there are many apertures on the top and around the ceiling, which can compensate the lack of daylight. This type of design shows the deep thoughts on providing bright areas with enough natural light. In the section below these divided areas are shown clearly. (Fig 5)

![Fig 5](image)
**Fig 5**, different lighting strength in a section of a traditional house, application of ceiling as a day lighting strategy

Other transparent element that was useful in light reflection and passing the light to the internal layers was water. Pool houses in traditional dwellings were usually in a layer around which different functions formed. These spaces had the ability to get the light from two sides, one was the open space or covered area and the second one was the roof. As far as these spaces have high altitudes, they have the chance to get the light from the apertures around the dome. The light from above is reflected after touching the water in the pool and brightens the area around.

![Fig 6](image)
**Fig 6**, the section of a pool house

By reviewing traditional architecture, it is evident that day light was an important element and it really created sense and meaning for the space. Different transparent spaces passed the light to other areas. Different elements in traditional architecture were responsible for passing the light and introducing it to other layers. Lack of day light in contemporary architecture is due to insufficient knowledge of traditional architecture. By studying contemporary architecture and extracting the useful elements of traditional architecture, this problem will be solved.

### 4 Study of Day Lighting and Transparency in Contemporary Architecture of Iran, Stating the Problem

Since 90 years ago, contemporary architecture of Iran has been transformed to what is seen now due to technological changes in the country. These changes were because of too many attributes such as, the decrease of family population, rise of consumerism and the consequent decrease in the consumption of the local materials. The shrinkage of the presence of nature in the dwelling area just as in the margin; and
finally, using electricity and variegated lighting systems instead of day lighting and oily lights [8]. All changes that were mentioned result in the loss of principles of traditional architecture of Iran, and the monotonic spaces of the house. Height alteration, open, and closeness of spaces, space sequences and many other cases are forgotten and lost. Day lighting in contemporary architecture is limited to façade windows from only one or two sides. (Fig 7)

Fig 7, the reduction of lighting amount, during housing transformation in Iran from A to C

A: day lighting in traditional housing, no neighbors obstruct the day light
B: day lighting in apartments with neighbors that obstruct the day light from two sides
C: day lighting in high rise, small apartments, one unit next to others can reach the light from only one facade

Following the advent of modernism in Iran, the fabulous architecture of the country transformed to copies of western architecture. Although it became successful in a number of cases, those architects who went abroad to study didn’t know anything about Iranian culture and style; so they started to expand the new copying style. The full glass facades became the fashionable style of buildings but the usage of these styles was not in order and in a proper situation. In modern or in a better word, in contemporary architecture of Iran (especially in housing), transparency can be divided into two groups; Transparent spaces and transparent elements. At homes, the definition and application of transparency has limited only to transparent facades or using transparent surfaces at the top of the buildings. However transparency has other functions as well. Transparency in dwellings of Iran, has the most usage in the level of façade, has the most use. Bringing the whole light in, using new reflective glasses, has gained the meaning of modernism and new architecture in Iran. People by observing these factors, classify the building as modern, no matter what the quality, or what they may encounter inside the building. The differences between traditional architecture and today’s life style have caused a tendency to modern architecture. Feature imitations from Europe or western architecture have made big holes in today’s architecture of Iran [5].

In the contemporary period, traditional houses were largely abandoned while apartment buildings became more prevalent. In the new type of residence, each household had smaller living areas and a shared courtyard (as opposed to the individual courtyard of traditional houses), which belongs to all families living in an apartment building. New building regulation, which allows buildings to cover 60% of the land parcel and left 40% for open space, had a great effect on the spatial organisation of houses as well as on urban design. The central courtyard is now located in the front and multi-storeyed apartment buildings became the dominant type of preferred housing [13]. The increase of land price and population has completely transformed the patterns of dwelling plans in Iran. The average size of housing units has been around 80 square meters over the past five years. At present, the average price of a housing unit in urban areas is about 10 times the annual income of an urban household. Average construction cost for 1m² of urban residential buildings in the first half of 2008 was $350 dollars [1].

Lack of daylight in the living room is due to absence of opening around this area. Bed rooms can access the day light from façade, and kitchen from the patio.

Fig 8, stating the problem in a small apartment of the city of Tehran
Another problem, which is as important as the cultural conflicts, is the climate. Iran is a large country with a wide range of climates. Tehran, as the metropolitan capital of Iran, is cold in winters and hot during summers. Due to this situation, glassy facades are not suitable because of the direct sunlight of summer and heat waste in winters. The heat loss and heat gain are both problems that cause lots of inconvenience from the dwelling area. The solution of these problems should include these problems as well. These changes in constructing areas has caused the decrease of light getting facades and made it limited to small openings and windows; for this reason the dark areas in houses appear. In Iran and especially in the city of Tehran, there have been so many attempts on having a modern city and using so many elements to make it perfect but because of the blind imitations of western architecture, so many conflicts have occurred. As Bianca conveys, there are some structural conflicts between traditional Islamic concepts and modern Western planning methods. Some examples of the conflict are different concepts of community structure, planning, and architectural forms [4]. The cultural conflict is the most important one. Most of Iranian people are Muslim and their habits and beliefs are mostly Islamic; however their appearance has changed. The privacy is one thing that through all these glassy facades and wide-open windows is lost.

5 Analysis

Through all issues mentioned above, a comparison about bringing the light in to the building between traditional architecture and contemporary one might be useful. According to Haeri, the most considering difference between past and present is the changing of dwelling plans that are compared as following. (Fig 9)

![Fig 9](source: Author, [8])

Before 1900

- Variegate daylight elements around the central courtyard
- Expanded dwelling area having open, closed and covered space
- Rooms are formed in one side of the courtyard
- Covered spaces are starting to go pale
- The proportion of open to closed space is completely changed
- Courtyard is such a relevant area for getting to the building
- Limited Side lighting windows brighten the dwelling area
- Courtyard is boundary of the house with neighbors
- Long plan, among other units that obstruct the light
- Getting the light from one façade
- Using voids for other facades to the light

Present

Fig 9, the transformation of housing plan, during one century, reduction of façade and daylight
Source: Author, [8]
From the comparison above, it is evident that traditional architecture was trying to give more value to humanity and fulfill man’s requirements. Creating different kinds of space for different functions, which was also flexible and had the potential to be expanded for specific ceremonies, was one of the abilities of this architecture. Day light and the connection with nature was one of the sub principles of traditional architecture. Having different kinds of openings and creating different spatial qualities, needing different level of luminance, can describe how much they paid attention to people’s feelings and the way they used to live. After about a century, the differences in building a house have been clarified. By analyzing these changes, the missed points that have caused the lack of light inside the houses, and the decrease of light getting surface in a house will be defined. By reviewing the transformation of dwelling plans, the decrease of sunlight façade will be determined. In this paper the gap between traditional and contemporary architecture, that has caused the lack of day light in the building, will be bridged in two steps. (Fig 10)

The first step is the spatial arrangement that is the division of a house into different lighting zones. These zones are separated areas with various functions and activities that need different amounts of daylight. The second group can be introducing the priorities of getting the light, which would be logical due to the shrinkage of dwelling spaces. Many buildings have a range of activities that have visual tasks and therefore different illumination needs. The nearest areas to the skin of building have the most chance for the best day lighting. If activities are zoned so that those that need the light are placed near the skin and those that do not are placed in the interior, then amount of relatively expensive skin and glazed openings can be reduced because of a smaller skin/volume ratio. The rate of electric light use, and thus heat gains are reduced [6].

The second step is using different spaces, as transparent ones and use them for passing the natural light. This means that by zoning a dwelling, it is tried to get the day light and give all the areas as much day light as possible. These zones and some functions do have the potential to pass the light to other spaces. For instance, kitchen as a permanent function, which cannot be omitted in a dwelling plan, has this condition. This means that this type of functions that need the natural light in the first place and are part of the public area can work as transparent areas. In a dwelling, there are different functions such as bedrooms, kitchen, toilets and bathrooms, storage room, living room, dining room, etc. These functions are placed in a specific lighting zone of the house that if this arrangement is right, most of lighting problems will be solved. Today’s apartments are limited by many units; therefore reaching the day light is limited to only a few openings on the façade, causing the dark zones inside the house. Introducing the light zones in a dwelling in this section can be divided in two groups. . Other zones are those that will not lose their functionality without natural light accessibility. (Fig 11)
After separating these two areas, it is time to put each space in its suitable place, which means that all bedrooms, kitchen, living room, or dining room have to be on the façade of the building or in the place that has the most luminance level. However through the shrinkage of dwelling areas, this fact is not possible. On the other hand, there must be another zoning to make some boundaries and make this zoning processes logical. In order to optimize all the spaces of a dwelling plan through accessing the natural lighting, it is proposed to divide the plan in to three zones, and extract the zones with potential of being the transparent space. In these spaces and the other zones there will be the utilization of different suggesting elements for expanding the natural lighting inside the dwelling area.

These three zones are as following:

- Public zone, with requirement of daylight
- Private zone, with requirement of daylight
- The zone of relevant spaces and services

In the plans below (fig 12), these zones are determined and it shows which one has the potential to work as transparent area and after that by using transparent partitions. After spatial arrangement of the plan, all areas can get a portion of day light.

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**Current situation**

![Current situation diagram]

**Application of solutions**

![Application of solutions diagram]

- Step a: the changing the location of toilet and kith
- Step b: the open wall, or transparent wall between kith and living room
- Step c: designing the window in the above part of the wall between bed room and living room

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Fig 12, diagnosing the lighting problem in a sample dwelling in Tehran, transporting different function to the right position and application of transparent elements

Source: Author
By determining different lighting zones in the dwelling, it is time for choosing them to become transparent elements. Transparency in dwellings can be such a solution for solving lighting problems. However all spaces cannot work as transparent ones. This fact is because of the privacy of the private zone of the house. Although bedrooms, bathrooms, and other private functions of the house need the direct and proper daylight, they cannot work as transparent space. This means that if the walls of the bedroom change to a transparent material and find the ability to pass the light to the adjacent functions, it might lose its privacy. On the other hand, some functions such as kitchen or living room need the proper daylight as well. However, as far as these spaces are in public zone of the house, they can lose their walls or even transform their walls into transparent material or form.

6 Conclusion
As far as the importance of natural light in human’s life is concerned, there have been severe attempts in architecture for bringing in the light. Traditional architecture of Iran is enriched of variegated openings, apertures and meaningfulness of the space. In contrast, contemporary architecture in the field of dwelling apartments is mostly empty of any spatial meaning. Today’s apartment lacks brightness and enough openings, which besides the building quality is a result of the lack of land size and increase in land prices. A small apartment in a street is surrounded by other buildings, and can reach the suitable light only from one side. Appearing dark areas in central layers of the house causes the discomfort and usage of artificial lighting during the day and this is the emblem of today’s apartments of Iran. Placing the functions that need the natural light on the façade of the building and using the light from public area that are adjacent to the façade were the main aims of this study. Transforming public spaces to transparent areas causes the light to be led to the internal layers, hence increasing the usage of daylight instead of artificial light during the day, and helping the energy saving of each house.

References: