



construction architecture Lightweight Iranian with indigenous materials

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Abstract

The research presented here may sound on the surface to have aimed towards aspects of the science of stability and the factors of stability which seemingly protect the buildings against earthquakes. But what is truly submitted here is but the reassertion and reaffirmation of the language of the Iranian architects of the past and the buildings they left behind where myriads of lessons are to be traced, fathomed into and learned by the generations to come. The multitudes of buildings that have lived to this day reveal the very heed paid by their architects and the knowledge they possessed. And we, as the recipients of centuries of experience and innovations are bequeathed with a body of wealth that should be fully examined, evaluated and fathomed in details in order to be used in the best and the most appropriate manner.

Keyword: *Architecture, Lightweight Construction, Technology, Iranian, Indigenous materials.*

1. Introduction

The Iranian architecture has always attracted most attentions onto its positive aspects such as logic, principles, stability, technical and scientific issues of the buildings, humanistic criterion, and the use of local materials, frugality and so forth.

Trial and error, frequent experiments, long-lasting experiences, proper use of the principles of geometry and proportions, paying heed with precision and care and intelligent approach towards issues were amongst the many platforms upon which the Iranian architects stood to view the broader scopes in solving the problems methodologically and perform mastery.

At the end, examples of the techniques used in the Islamic and Iranian architecture in lightweight construction with the use of indigenous materials will be mentioned.

While the use of the polarity of strength performed with prowess and utter awareness Had always produced the best result in creating balance and a steadfast harmony the reduction of the dimensions, facilitated the creation of appropriate forms and dimensions.

The ancestral body of knowledge filled with instructions, styles, methods, experiences, as well as the experimented examples has always been available to architects to be used and be evolved on a constant pace. Benefiting from the polarity of strength, and discovering the ancestral geometrical results overshadowed by the constant experiences and experiments have naturally reduced and diminished the abrading elements causing the creation of buildings

with covers of a more delicate nature and greater strength.

The Iranian architects have mostly been concerned with and focused on the factors of tear and wear in the buildings. Their attention on diminishing the causes of abrasion, and reinforcing the strength of the buildings is monumental. The prevalence of such multi-functional methods at this stage often seems either useless or ornamental in the eyes of those who are not familiar with such techniques but we should know that in the Iranian architecture nothing is ever used as merely ornamental. Whatever is done and used is based upon essentiality and usefulness which in itself is aesthetic and conveys a sense of beauty. The creation of mantel and niche are performed to lighten and relieve of a burden in the sections which are not quite bearing. These recesses are also used to serve other purposes such as accommodating items of the daily use. Building the artificial roof, wooden mesh, double-covered roof for temperature and sound isolation and so forth were done to create a space to fully meet the needs of the daily life.

In a large region of Iran, the use of natural dirt by shaping it through heat and also the use of a more advanced method like baking the bricks were very prevalent. Brick which is categorized as a heavy material was one of the basic materials in the Islamic architecture. The pressure-resistant bricks have originated or caused the building of the bearing-walls, arches, and domes. The following will describe a few examples of "Lightweight Construction" in the traditional buildings of Iran:

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1-1 The use of Dome

One of the methods of mass-reduction of the roofs is the use of the domes which is a resistance-element against earthquakes. It keeps the building stable. And since the ratio of the mass to its volume is minimal it is one of the best forms. (Figure No. 1)

2- Changing the thickness of the cover of the dome

One of the innovations of the Iranian architects in building the domes is the changing of the thickness of its external shell or cover. Up to the point of "Shokrgah", (locale of thanksgiving) they used the 22.5 with one type of a thickness and from this point on they changed the thickness. The same strategy was applied in the 67.5 angles in which a brick would be taken out to reduce the thickness. (Figure No.2).

3-Building the corners in Domes

One of the most important issues in the history of the world's architecture was the transition from a square surface into a circle in the space. The Iranian architects were the very first ones who solved these problem eons ago. The innovation of such transition dates back to the Ashkanian or Parthian period (129 BC-224 AD) which began to evolve thereafter meandering through the Sassanid and Islamic periods. The Sassanid elevated their designs into the peak of maturity.

In order to cover a square surface with a dome, they needed to convert it into an octagon and then into a polygon of 16 sides and angles and finally into a circle a process which was only possible by covering the corners.

The issue of making corners in domes in itself is one of the cases which are so significant in the creation of the space, the reduction of the height of the space and their proportions as well as its relation to the structure. The hollow corners are also very effective in the mass reduction of the roof.

The second dome is the "Djame Mosque" in Isfahan which was built behind the northern Iwan (Portico) in 481(Hijri) The height of the dome from its peak to its foot on the ground is about 18.5 meters with a mouth of approximately 9.5 meters. The dome is built on pillar of approximately 3 meters thick. The transition or conversion had been performed from a square surface into an octagon, with arches in the inside with 16 sides and then a circle. (Figure No 3).

4- Lightweight Construction around the tall neck of the dome

The use of the above-mentioned techniques (Shekanjha) in transition from a square surface into a circle and the bearing capacity of the dome by the arches would facilitate the process of reducing the weight of the sections situated underneath the arches which are placed on the sides of the square. The peak

of the light is in the spaces beneath the dome of the houses. Around the tall neck of the domes light receivers are installed. Not only they balance the weight of the building but also they conduce to sufficient and indirect light into the interior. (Figure No. 4).

5- The use of narrow arches in the domes of "Tarakin" (cracked)

Another type of dome building is the "Tarakin" domes with narrow arches. The innovation of this kind of building can also be attributed to the Iranian architects. The cracked domes are made of cracks in between each crack the stucco groin are installed which later turn into a narrow arch. The integration of these cracks and the narrow arches produce a stable and steadfast system. When the cracks are housed in the narrow arches a light cover is placed. [2]

The use of narrow arches and groin for the skeleton of the dome is to facilitate the reduction of the weight of the dome in the covering area but not the bearing. (Figure No. 5)

6-Double-shelled domes and mass reduction in between them

The principle of proportions in the interior and exterior of the buildings and the harmony between them which in a way counts as the modern mass-reduction architecture results in the creation of the two-shelled domes which have an interior and an exterior shell. The exterior shell of the dome is the main structural one which is resistant and strong. The interior shell adapts to the needs of the daily life and accords with the environment of living. (Figure No. 6)

7-The use of "khancheh-covered" (type of arch) curves in the lightened roofs

To make the roof lighter and instead of filling the building materials with dirt and sands, despite the existence of the curves which are used as the bearing structure and roof coverage, the "khancheh poosh" (type of arch) curves are used. This method serves useful purposes. Not only does it keep the building materials junk-free, but also the creation of the khancheh (Arch) curves will reinforce the strength of the adjacent curves where they want to be free from the burden of the weight. But these khanche (Arch) curves which help the original curves play a great role in relatively harmonizing the diaphragm of the roof. Keeping the upper curves hollow with the "khanche poosh" curves, not only reduces the weight but it also adjusts the temperature of the interior and exterior. (Figure No. 7)

8-Lightening the walls and pillars with buttresses

“Djebelieh Dome” in Kerman is assumed to have been attributed to the beginning of the Islamic era. This dome is situated on an octagon. The thickness of its wall is approximately 3.10 meter, its mouth about 12 meters, and its height, from the apex to its foot on the ground is about 10 meters. This building has been lightened by the use of arches? and this is one of the characteristics of this building. The thickness of this dome, at the height above the thanksgiving area is around 1.80 meters but as it extends up, the thickness immensely reduces into 60 centimeter. (Figure No. 8)

9-Keeping the inside of the Minaret hollow or void to reduce its mass on the top of the minaret

Minaret, in the traditional structures is one of the characteristic elements. It is a structure of limited aspect with a tall height which has to create a role. Hollowness is one of the outstanding characteristics of these minarets and the reason is to be found in their massiveness and the frequency of the movements of the earth. Like domes, the ratio of their mass to their volume is minimal. On the other hand, the highest point of the minaret known as “mazaneh” is the lightest. In fact, the final portion of the minaret is the lightest while at the bottom the heavy materials with high mass are used specially in the foundation where heavier materials are applied. From the midpoint up, the mass of the minaret begins to gradually decrease. The section underneath the Mazaneh of minarets attaches the console of Mazaneh to the trunk of the minaret through Mogharnass (tall Building) designs. These Mogharnasses (tall Building) are usually light and hollow.

The minarets of a mosque or a religious building could not only create a special atmosphere but also get situated along the base of the large curves of the entrance to respond to the force power which in any case are born of the curves.

It is therefore rather hard to be able to deny that the spiral staircase used in either the interior of the minarets or inside the thick bases of some of the buildings have merely applied to facilitate the passing through one level to another and their wood is used to connect the sides of these bases and the hollow inside they produce is to reduce the weight. It is hard to say that they were not appropriately used. [4] (Figure No.9)

10- The hidden arches behind the facades

The creation of “void” above the Iwan (Portico) which look closed on the appearance of the façade but actually there are curves in the inside for mass reduction purposes.

11-Konoosazi (Build the little arch) and mass reduction

In the cradle-like and dome-like structures Konnosazi (Build the little arch) is used which is a preventive method to prevent the force of the adjacent arches of a bearing wall and to avoid the waste of materials. In Konoo sazi (Build the little arch) of the areas around the cover a canal is produced that if the two extremities of this canal don't close in the façade then it will function as a channel for air ventilation if an opening be installed on the shoulder of the arch through the canal. This will be a method called secondary louver in this cover. [3] (Figure No.11)

12-Mass reduction in walls with mantels and niches

Due to the use of the heavy materials there are massive weights in the walls and the masons of the past by curve capping, hollowing the walls' pillar in the form of mantels and repeatedly using curves and hollowing the inside of the walls with consecutive curves would reduce the walls' mass. On the façade of the walls while the arches convey an ornamental aspect, they also help to reduce the mass. (Figure No. 12)



Figure 1: The reduction of the mass ratio to its volume is seen in the Mosque of Sheikh Lotfollah in Isfahan.

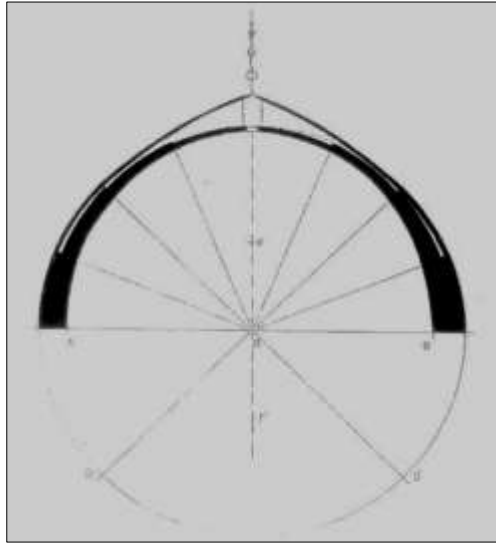


Figure 2: The reduction of the thickness of the arch from the bottom of the arch to the top of the dome in mass reduction.

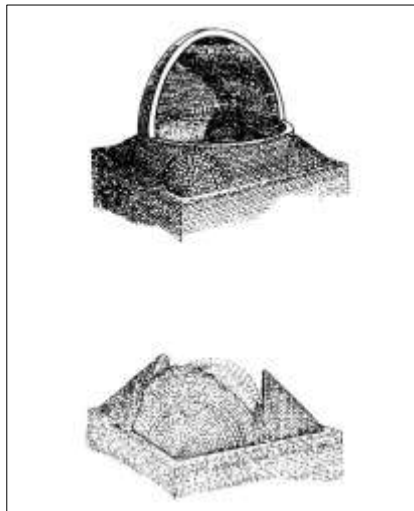


Figure 3: Corners built in the “Djame Mosque” of Isfahan with the use of the least amount of materials but most stable form wise.



Figure 4: Mass reduction and the provision of light by

installing light-receivers around the tall neck of the domes.

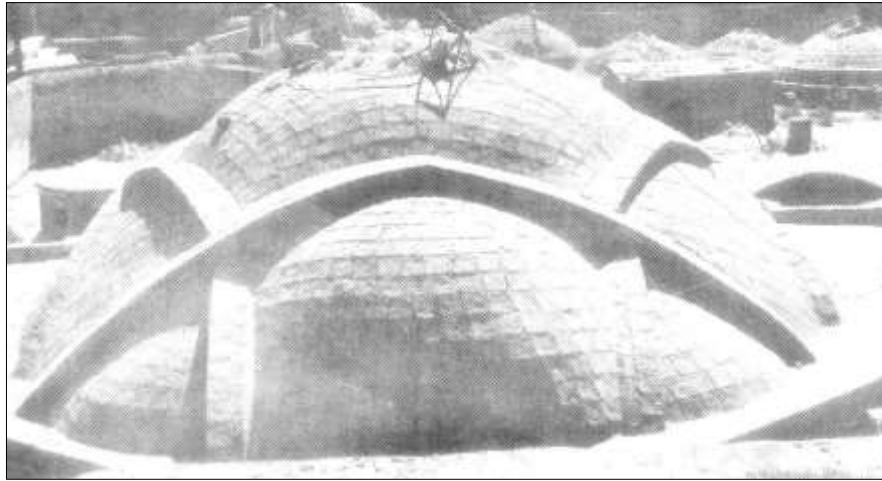


Figure 5: The use of the narrow arches and groin in the skeleton of the dome is to facilitate the reduction of the weight in the roof and the covering arches.

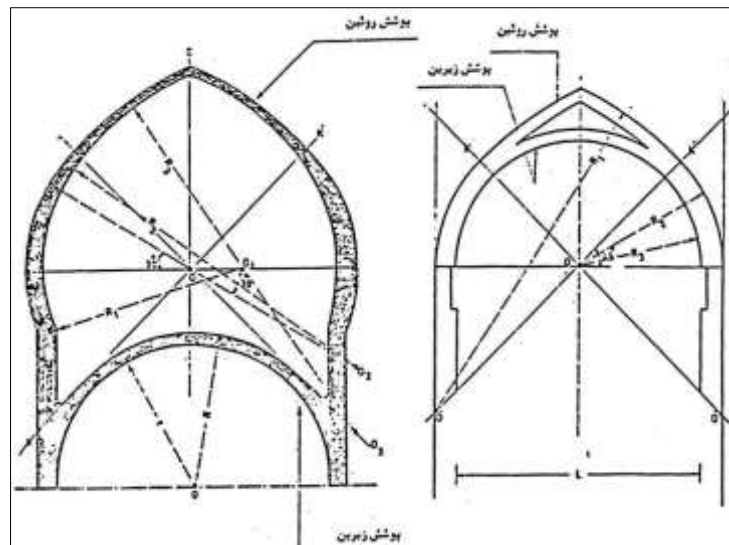
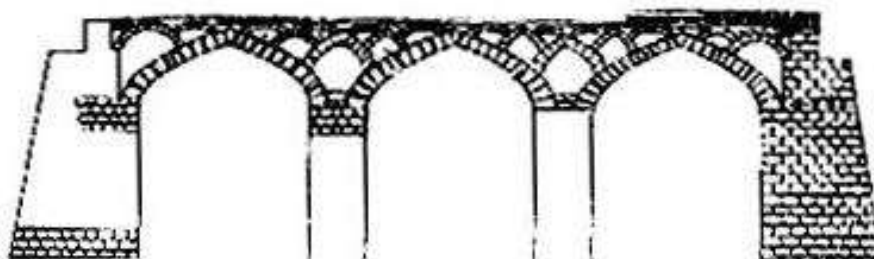


Figure 6: This is a sketch of a mass-reduced roof with the use of two-layer covers



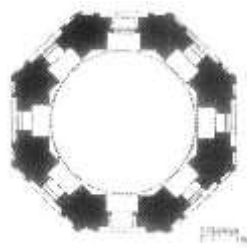


Figure 7: The method of lightening the walls and the bearing pillars by the use of mantels and curves. (Plan and perspective of Kerman "Djebelieh dome")

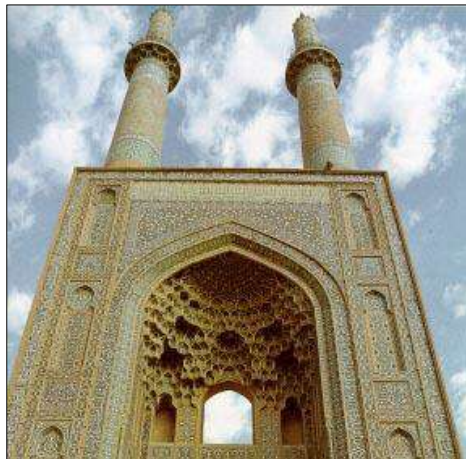


Figure 8: The gradual reduction of the mass of pillar and the minarets in proportion to the height, their hollowness and the mogharnass (tall Building) work. (The top of the entrance of "Djame Mosque" in Kerman)



Figure 9: Bam, Konoo sazi (Build the little arch) to build a mass-reduced roof and preventing the possible movements



Figure 10: The mass reduction going along with hollowing the walls and the roofs at the height, (Right: The tomb of Moshtagh Ali Shah in Kerman) (Left: School of Agha Bozorg in Kashan)



Figure 11: The reduction of mass with the use of heavy columns, the elimination of voluminous or bulky walls and the use of light shells or covers in order to “khancheh poosh” the roof. Shiraz

Conclusion

Architecture is a combination of science, art, passion, taste, conviction, faith and special skills which in the process of culture and civilization and on the path of history has its own expressive language. Technology is a civilization instrument and the fact that the Islamic civilization could take leadership over a vast area of the world for many centuries reveals very clearly that this civilization was essentially based upon a significant and sturdy technology. Our country is filled with the experiences and examples that denote the knowledge and wisdom of our ancestors regarding the architectural field. The country of Iran with its vastness and various climatic conditions is one of the rare countries which could fulfill its own societal needs throughout its long history, without any reliance upon the skills and expertise of outsiders. The scholars of that time benefited from mathematics and brought geometry into the service of architecture. They knew the forces and were very well aware of its movements in the mud-made buildings. The discussion entitled as “lightening method” in the structures was a topic of so much attention and heed paid by our masons in the past. And we, as the inheritors of this great body of knowledge and innovation should research and fathom this treasure with utter perseverance and passion without which no fulfillment will be achieved. In search of the crystal ball was my heart for years, seeking what it already possessed from others.

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