Historical vaulted constructions of the Iranian heritage.

Stefania Petralla[1]

[1]Department of Civil Engineering and Architecture, Bari Polytechnic University, Italy

ABSTRACT

Brickwork, upon which architectural building is essentially based in Iran, was initiated by masons who, all along the Islamic period, made brick art never lagged behind other arts.

In Iran, although the most primary construction materials, bricks soon reached height of perfection, thanks to the existence of master craftsmen in the country and the favorable climatic conditions.

Bricks were the principal building materials which gifted master artisans, competing with one another, came to use in an uninterrupted string of innovation.

Above all, vaults represent one of the masterpieces of local architecture, with peculiar constructive techniques, never developed abroad. Since in Iran these structures have always been made almost completely of bricks, they necessarily had to develop closely related to the material potentialities.

Accordingly, buildings have to possess a configuration suitable with the use of weak materials and the survival of these buildings proves that they possess to some extent the potential to resist earthquakes too.

This paper, to understand the characteristics of these elements and their involvement inside buildings of the vernacular heritage, will focus on the construction and designing processes. This by means of a few examples and paying attention to the materials used and the way in which the structure operate to generate a certain form.

The examples selected are inside the bazaar of Tabriz, actually partially considered in the list of the World Heritage for their prominence.

Thus the aim is to point out the potentialities of a so poor material, as well as the constraints and the limitations of this architectural heritage, from which we may learn possible lessons to rehabilitate technologies and designing processes and to try to merge together tradition and innovation.

INTRODUCTION

The Islamic architecture of Persia has a strong identifying character mostly due to the specific use of the basic material used that, over time, acquired record levels of manufacturing. The craftsmen of Iran in fact, during the first centuries when they started working with brick as a main material, developed a wealth of technical resources never equaled elsewhere.

This caused the exceptional merits of Persian architecture to be attributable to some extent to its own use and management.

In ancient Iran, brick art pursued its evolution. Islamic art exclusively utilized bricks, masterfully taking advantage of its qualities as an essential building element. Thus mosques, palaces, houses and even bazaars appeared all based upon bricks, the basic materials of every man-made construction.

The brick of this semi-desert zone does not possess the tensile strength of stone, and is further weakened by the need for frequent mortar joints.

The composition of today mud-bricks is essentially the same as in the past and consist simply of mud mixed with straw, found as close as possible to the site. In order to secure a proper fit between the consecutive layers, the best choice was a rectangular mold, which adopted various sizes and proportions in different times, and served in shaping bot sun-dried and fired bricks.

The dimensions used have been modified in the different ages and are today widely standardized. In pre-Islamic era each brick was large from 38 to 50 cm on one side, usually slightly elongated and for the most part from 9 to 12 cm thick. The currently used brick, raw or cooked, continuing a tradition extending back to the pre-Islamic period is squared, but usually with dimensions of 25x25x5 cm or 20x20x5 cm, held together by gypsum mortar.
The good behavior of the bricks arranged following different patterns is partially due to the good adhesion of the chalk proper of this area. The Iranian chalk differs from the one used in Europe and, accordingly, has a different behavior [1-2]. Thus, the availability of this gypsum mortar obviously played a role of primary importance, in addition to brick.

Thus, forms had to be adopted that, under uniform loading conditions, exploit masonry's resistance to compression. Among these arch, vault and dome were the simplest and led to forms and solutions recognizable far beyond this original territory.

Moreover, choosing a material more durable than wood and cheaper than stone has to be linked with territorial needs. In fact this territory is also suffering for shortage of timber. So alternative methods of spanning between walls had to be found, not necessarily related with the use of centering.

In Iran, the construction of such kinds of vaults and domes is developed in continuity with the use of a basic architectural element that has facilitated the creation of the coverings. This key element is the arch that, thanks to the use of the particular chalk, has been able to support experimentations and develop several declinations [4].

In the Iranian area the arch becomes the basic architectural structure of the building system as well as a significant element influencing the formal composition of the coverings. The arch in fact, being positioned from time to time to join two edges of a plan, makes it possible to cover huge spaces by fractioning it, thus becoming "the starting point of the architecture."

Furthermore, the several possibilities it enable, allow for an easy and fast covering of irregular rooms too. This gave rise to a process that involves both the structural and the formal design of the buildings, developed on the basis of the prominent use of the geometry for the construction of the architecture.

The first coverings are using the arches as diaphragms, thus to separate or connect little squared cells. Moreover they are arranged to create radial supporting structures inside the domes of quite all the single domed rooms.

Over time, especially since the 11th century, arches have been placed inside coverings not only parallel to each other or converging towards a single central point.

After shortly the introduction of this solution, the experiments and the aim to create more adaptable shapes led the arch to become one of the main features for the Iranian architecture, thus showing an excellence for the management of this element through an intense developing structural and technical proces

SIMPLE CROSS VAULTS

Thus, due to the fact that in Iran the buildings have always been made almost completely of sun dried bricks, they necessarily had to develop closely related to the material potentialities together with the relative lack of timber. These needs, together with the introduction of the arch as bearing structure, led the technique of building vaults and covering without formwork to become dominant in this cultural area.

The kind of vault most immediately answering to these necessities and thus firstly employed is the cross vault. These vaults, realized above square cells connected by meaning of the arches, most frequently are showing masonry apparatuses with the dovetail or herringbone patterns, consisting in courses arranged on diagonally tiled planes, perpendicular to the groins. (Figure 1)

Figure 1. Restoration site inside the Bazaar of Tabriz. The picture is showing the creation of a vault without centering and the disposition of the squared bricks.

The first solution is the one providing simpler kinds of self-supporting courses made stable by the shape they are arranged with. When design became still more refined and masons set out to produce yet more significant work, this methodology and the way of execution have been fully exploited leading towards several formal and spatial declinations.

With changing architectural styles in the course of successive periods, many innovations were introduced: everyday new buildings rose from the ground, adding their sight to the sky-filled landscape.

The possible declinations of the local techniques of the construction allowed for the possibility to cover even irregular planes. Thus, by the use of the arches to connect two points of the space they have been able to create interesting solutions and anomalous patterns.

Since in Asia vaults are related to symbolic expressivity as well as to primary needs, it is very frequent to find out original application for the decorative and structural patterns inside quite all the ancient Iranian urban fabrics.

The attention has been focused on some buildings part of the urban fabric of the old centers trying not to focus on well-known religious or royal ones.

Far from being the result of a well-planned design process, these constructions are showing the spontaneity of the local techniques. Thus resulting as the most immediate possible answer of the local architectural tradition.

The bazaar of Tabriz is an extremely interesting architectural system, actually still not deeply documented and not well known even if partially inserted inside the UNESCO World Heritage Monuments List [3].

Since Tabriz has always been an important stop for the ancient commercial routes, the structure of the bazaar has always represented an attractive pole for the city. It has been restored in the 80's after the damage and the partial collapse due to the frequent earthquakes affecting the area. It is showing several interesting buildings or spaces covered with intelligent and particular bricks solutions.

For example, within the main and secondary commercial streets, a unique series of vaults showing original brick patterns is set out. (Figure 2)

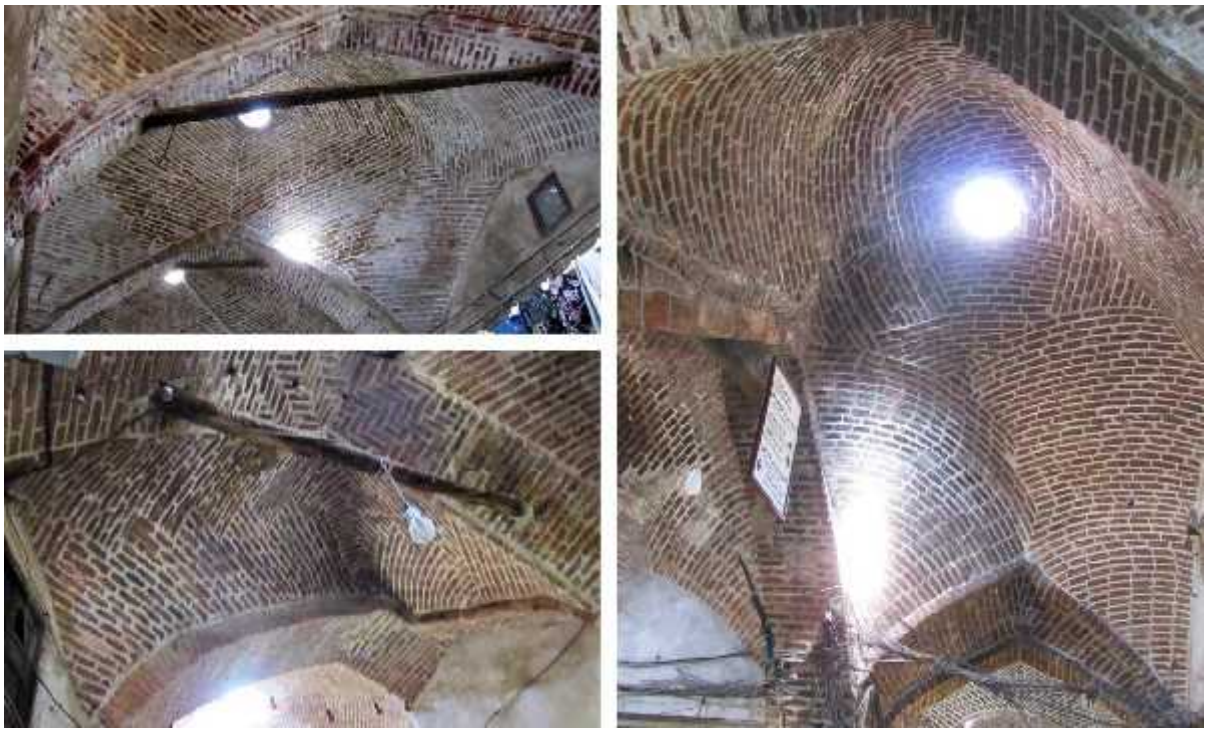

Figure 2. Pictures of the bazaar of Tabriz showing the irregular disposition of the bricks inside vaults realized without the help of the centering.

Related to the need for covering irregular portions of the space, these little "cells" not necessarily embellished or decorated, are representing the most spontaneous aspect of the local architecture.

The cells that are composing the commercial streets are thus presenting simple vaults realized without the use of centering in most cases with bricks disposed with simple dovetails or herringbone patterns.

When the creation of a covered space involves more irregular plans it is possible to point out original bricks arrangements due to the need for a handily and quick construction.

COVERING THE TIMCHES

In a place like Iran, with significant geographical and climatic challenges and with the relative lack of some materials, architecture clearly expresses the "genius loci" and has to be its expression contextualized in a precise historical moment.

Considering that the vernacular architecture bases all its experimentations and improvements on a unique cultural heritage, it is possible to find and understand the mutual influence of the different models in a defined context.

Accordingly, historical and widespread solutions represented the first answers to some needs that were later solved by introducing new methods and shapes.

These introductions allow the building to be the expression of a changing and developing culture.

The existence of a certain number of magnificent and big commercial buildings expresses the synthesis between the high performing masonry techniques and the fruitful use of the arches inside this culture.

Over centuries, the commercial streets made up of covered “cells” connected by arches, have been flanked by a series of big buildings for the trades.

These architecture, contrasting with the elementary and simpler covered streets, are the expression of a solid and acquired constructive tradition and show a full awareness of the technical devices and of the related design processes.

In fact, by using complex systems of bearing arches and structural devices made up with bricks, Persian workers have been able to create magnificent spaces as the result of a full management of the vernacular methodologies.

Once again it is possible to find out these features looking at some two stored commercial spaces part of the Bazaar of Tabriz. (Figure 3)

Figure 3. Bazaar of Tabriz. Inside view of the ceiling of the Timche Haj Mohammad Qoli.

Along the commercial streets, the Bazaar of Tabriz is connecting several huge spaces that show a rich collection of experimentation and declination of a unique feature.

In spite of a big number of experimental solutions, making the supporting arches for the vaults of these buildings can be considered from a technical point of view as the reiteration of a well-known and good working rule of knife-shaped bonding.

In fact, all these vaults are realized by the use of connecting big arches that are working as ribs. The variations, that help to create different formal declinations and often creating

inner and outer shell with substantially different profiles, are mostly concerning the disposition of the ribs.

Differentiating the internal spaces and the external appearances of domes rapidly spread throughout various regions of the Middle East and Central Asia, thus contributing to the creation of a new topic: covering in several stages, with intrados and extrados completely independent of each other.

Indeed these become the basic topics that were to affect the style of much of the vault architecture that spread later on.

Shortly after the discovery of this quick and repeatable technique, taken from the ancient and solid brick tradition, several types of ribbed structures arose.

Therefore, the advantages they allowed, which implied a high level of craftsmen knowledge, gave way to an extremely wide distribution of the system of load-bearing ribs within the Persian territory. This spread and full control of the system gave workers a greater willingness to experiment with new structural and formal solutions.

CONCLUSION

Starting from the Safavid period during the 16th century, the relationship between form and structure, from this moment on, seems to be as ambiguous as ever.

Very often, the structural part is completely hidden and not at all expressed in the inside space. In any case, however, the concept at the base of the construction is the need for a prototype of interior, with a creative freedom allowed by the solid basis of a fully acquired constructive technique.

Examples for this stage of the Iranian creativity arose during the 16th century and are largely widespread later on.

In the Qajar period quite all the vaults of commercial, residential and religious buildings are constructed by using complicate structural devices quite always not visible at all.

In fact from this component, an intricate system of timber hangers develops which, attached with lumps of gypsum mortar to the brick structures to suspend the muqarnas vaults (a sort of corbel used as a decorative device), again gives local Iranian slant to a typical Islamic topic.

Iranian muqarnas, even if recalling a well-known Islamic element, are made in a way that has never been well-developed abroad. Actually they are realized as a lightweight design made with chalk and sometimes wood. (Figure 4)

Figure 4. Masjed Kabud, Tabriz. Picture showing a decoration with little muqarnas in the corners, realized with tiles and chalk. The absence of the tiles is showing the shape of the structural part made up by bricks.

Thus from the structures, wooden brackets are hung by using ropes with gypsum mortar. After these corbels are hung, the filling parts are completed by chalk and eventually covered with tiles.

The importance that Iranian architecture attributes to the formal symbolism and to the spectacular impact together with the improvement of the decorative devices following the taste, leads towards the creation of structures that, originating from the same matrix, gives the slant for several different features and models.

Among them it is possible to find strictly local decorative devices called yazdibandi, qatārbandi and sardārbandi that, from a certain moment on are sublimating the expressive value of the architectural element of the Iranian vaults.

REFERENCES

[1] Galdieri, E. (1979) Isfahan: Ali Qapu. An Architectural Survey (Restorations-IsMEO), Roma.

[2] Petralla S. (2012) "Arches and Ribbed Vaults of the Iranian Tradition" in *online Proceedings of the International Symposium Masons at Work. Architecture and Construction in the Pre-Modern World.*

[3] AA.VV. "Tabriz Historical Bazaar Complex," in *UNESCO World Heritage Convention, Nomination of Properties for Inclusion in the World Heritage List.*

[4] Petralla S. (2012) "Safavid Ribbed Vaults as a Masterpiece of Iranian Construction Techniques" in *Proceedings of 4th Conference on Construction History*, vol. III.