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Dome on Squinches
(The Persian structural solution for architecture)

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Abstract

Innovation in structural technology is one of the valuable works of ancient Persian architects. There is no structural separation of architectural elements in the Persian architecture. Domes are of the important elements in Persian architecture and were usually built over important spaces or in special buildings. The Three dimensional form distinguishes it from the city context and makes it a landmark in the landscape and silhouette of the city. Persian master builders had introduced an architectural innovation which had an imperishable effect on dome architecture in the Middle East and Central Asia: surmounting a dome on squinches. The present paper presents an overview of the squinch element and the construction process of vaults and domes which are built on squinches. The paper also introduces some Persian buildings with this dome structure.

Keywords: Dome, Vault, Squinche, Persian architecture, Sassanid Era

1.INTRODUCTION

The combination of structure and architecture brings about a composition of technology, art and aesthetic values. It needs knowledge of structural and constructional systems and acquaintance with materials and their behavior. The fact that architecture comes into being only in combination with structure makes the consideration of foundation, columns, ceiling, etc. inevitable.

In different eras, architects paid attention to the rules of load transference, position of supporting elements and their connection with other structural elements, diminishing of forces in the walls led to elimination of unnecessary mass and reducing weight.

Vaults and domes were the most important elements in Iranian buildings until the beginning of the 20th century. The fundamental contributions of Persian architecture in dome development in the Middle East and Central Asia are firstly the establishment of the foundations for using masonry domes to cover the chamber halls, and secondly the innovation of an approach for transferring from the square to the circle, namely, squinches which mainly appeared in the Sassanid period. Domes are certain elements of Persian architecture which were widely developed after the coming of Islam. They differ considerably in type and shape. Persian domes and vaults are commonly well-known due to their various typologies, proportion of components, specific forms, and graceful designs.

This article investigates a particular type of domes and vaults which were built on squinches.

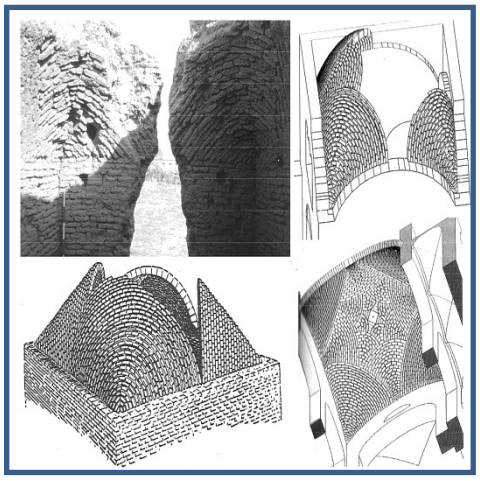

Figure1. squinch vault (Herrmann 1999)

2.SQUINCH VAULTS

The squinch vault shares the structural and technical concepts of the Sassanian vaults. This sort of vault is also known as ‘khorassani’ due to the geographical area where it is more commonly found (NE Iran), or even “balkhi” in reference to the city of Balkh (present day Mazar-i Sharif, Afghanistan).

The construction process starts with a small arched course laid in each corner of a square room, advancing with new and increasingly larger arches

leaning on the previous ones, defining thus four corner half-cones that meet in the center of each side of the room (Fig. 1). (Herrmann 1999)

The remaining square opening could be covered by continuing in the same way, as is done still nowadays in Khorassan, or by re-starting the process from the newly created corners.

Squinch vaults were apparently hardly ever used in early Islamic monumental structures, as no samples from this period have survived. The only surviving vaults are later: in the east we have those from Khorassan (Iran and neighbouring Turkmenistan & Afghanistan) houses and from the congregational mosque at Isfahan (the vaults are from the 10th C.A.D. onwards). (Copani & Buonanno, 2003).

3.SQUINCHES WITH STEP FORM

These types of squinches domes are related to concept of squinch-vault. In these cases the squinches do not need anymore to span the corner of a square room but small sections of an already circular plan, becoming thus almost a true spherical surface. The decorative effect of this solution, similar to a scale-pattern, would gain a decorative value by itself.

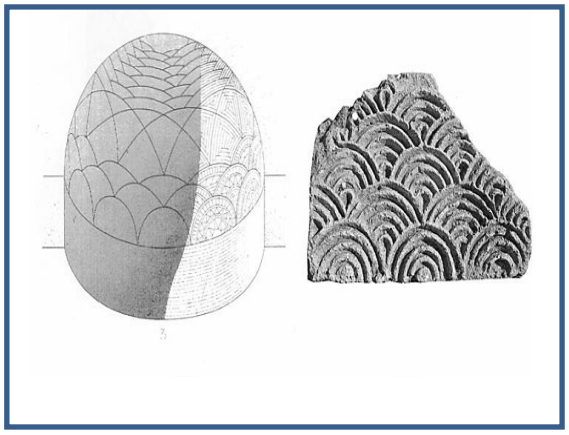

Figure2. Stepped squinches dome and 'scales' pattern and springers of spheric vaults (Reuther 1939)

4.DOMES ON SQUINCHES

The Sassanian-origin domes on squinches can be seen as a particular case of the squinch vault described above. In this case the four corner half-cones (or half-conoids, if its profile is a parabolic one) are not carried to the middle of the room, leaving some space between them that is filled with horizontal courses, until a horizontal circle is made at the crown of the squinch arches, on which the dome will rest. The dome has a half-elliptical section and is built with horizontal circular courses, without using centering, by means of gypsum mortar (Fig. 3). In the dome over squinches in the "Sassanian palace" at Sarvistan, Iran (L. Bier, 1986), the transition section, formed by the drum with the squinches, is made of cobbles and roughly cut stones embedded in gypsum mortar (as are most of the building's walls), but the dome itself is built with bricks. (Fig. 4) Meanwhile in the dome over squinches at the Ardashir's Palace in Firuzabad, the squinches and the dome are both built with cobbles embedded in gypsum mortar. (Fig. 5)

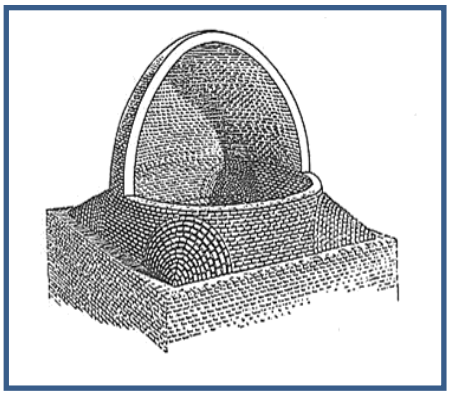

Figure3. Dome on squinches (Reuther 1939)

Figure4. Dome of Sarvistan palace (www.panoramio.com)

5.SQUINCHES DOMES SUPPORTED BY LINTELS

A singular case of lintelled squinches was recently discovered, at the Amman citadel palace,

supporting the dome over the throne hall. (Arce 2000)

This element was composed of several stone-cut elements (Fig. 6): Firstly the ones forming the "beam" or squinch lintel itself, originally a timber beam that, translated into stone by stonecutters, becomes a three-piece "flat arch". It is composed of two lateral corbelled pieces embedded diagonally into the wall corners, and a "key stone" that fits between the two corbels with a joggled joint (Arce 2005).

These elements, due to their wooden origin, were decorated with a semicircular molding in their lower section and with a couple of rolling corbels in the areas close to the wall. In their back face they present a recess to support the coffered triangular slab that serves as a ceiling for the space spanned by this composite lintel. Traces of the stone carved cornice, recalling also a Sassanian pattern of teardrops, that was placed at the base of the dome was retrieved from the site as well. Most probably, the dome on top of these squinches was built with a Sassanian technique using cobbles embedded in gypsum-based mortar, and with a slightly parabolic section. (Olavarri 1985).

Antecedents of this element are still nowadays a standard roofing system in the North of Iran and the neighbouring regions as Azerbaijan, Georgia, Armenia and Tajikistan (Arce 2000).

Figure5. Dome of Ardashir's Palace in Firuzabad (www.flickr.com)

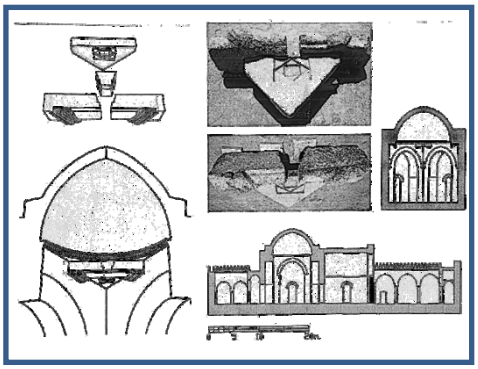

Figure 6. Domes on Lintelled Squinches. Amman Citadel Throne hall (Arce 2000).

6.THE DIFFERENCE BETWEEN PENDENTIVES AND SQUINCHES

Even though the term of dome has been used similarly in different literatures both in the Eastern and Western architectures, there has been a major architectural contrast between the compositions of their spatial elements. While Eastern domes were supported on squinches, Western domes were systematically erected on "pendentives".

The main attribute of pendentive dome's construction is that it does not require column and beam construction. The upper dome is supported in either ways, by round arches or a dome-base structure. The upper dome can be constructed on the arches instead of being directly constructed on the ground (Pasic & Siravo, 2004 and Unsal, 1973). Pendentive is a triangular section of vaulting between the rim of a dome and each adjacent pair of the arches that support it. Any of these triangular sections of vaulting, positioned at a corner of a rectangular space to support a circular or polygonal dome.(Wikipedia.com) The constructional difference between squinches and pendentives is shown below. (Fig. 7 and 8)

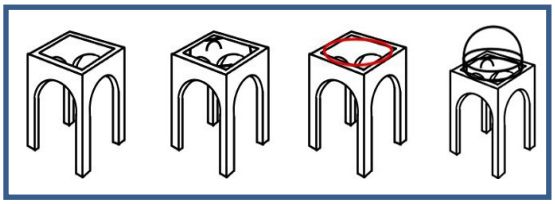

Figure 7. Dome construction process on squinches (www.essential-humanities.net)

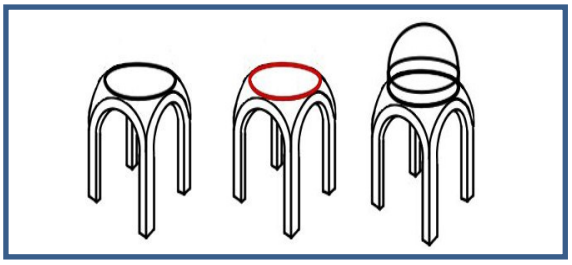

Figure 8. Dome construction process on pendentives (www.essential-humanities.net)

7.CONCLUSION

Persian architecture has a continuous history one that dates back to more than 6,000 years. Still, it doesn't fail to fascinate us with both its architectural and aesthetic value which was considered to be "magical and in vocational in character". Sassanid architecture refers to the Persian architectural style that reached a peak in its development during the

Sassanid era. In many ways the Sassanid dynastic period (224-651 CE) witnessed the highest achievement of Persian civilization, and constituted the last great Persian Empire before the Muslim conquest. In fact much of what later became known as Muslim architecture were taken from the Persians into the wider Muslim world. During this period, the most essential innovations occurred in dome architecture with the construction of semi-elliptical domes which were often erected on reception halls of palaces. The Persians solved the problem of constructing a circular dome on a square building by the squinch. After this Era and even nowadays architects use this historic innovation to construct the buildings with wide spans.

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