

Ehsan Abushadi

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O’Kane

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The Evolution of Islamic Arches till 1250

Arches are a common feature of early architecture; they were an effective architectonic form originally used to support a building or roof, while creating a sense of vastness. It rapidly integrated into the architecture that developed within Dar al-Islam. Their design and purpose was simple, but as time progressed through the Islamic Empire, with dynasties replacing the previous ones, arches started to develop in shape and decoration, becoming increasingly less simple through the centuries. The development of arches was not monotonous or homogenous throughout Dar al-Islam, due to its large expanse each area developed differently, being influenced by local architecture, context, artisans and masons.

If we accept the generally correct 19th century theory “that buildings could be dated by the shape of their arching”¹, then we can clearly say that each type or shape of arch is specific to one period. Therefore, these period specific arches cannot be of random shapes or forms as they must form some sort of smooth transition from one period to the next. In other words, there is an evolution of arches.

Amongst the first arches to be used are the semicircular arches. We find examples of these early semicircular arches at the Great Mosque of Damascus², Syria, after the modification by Al-Walid, 705-15; arches that might have been inspired by those that existed at the temenos

¹ John Warren, “Creswell's Use of the Theory of Dating by the Acuteness of the Pointed Arches in Early Muslim Architecture”, in *Muqarnas*, no 8 (1991), p. 59

² K.A.C. Creswell, *Early Muslim Architecture*, New York: Hacker Art Books, 1979, vol. 1.1, p. 161

prior to the arrival of the Muslims to Damascus. The semicircular arch is also adopted from Byzantine architecture³, which was prominent amongst Christian monuments in Syria. Other examples of the semicircular arch can be found at the Umayyad palace of Khirbat al-Minya⁴, 705-15, Lake Tiberias in Israel/Palestine; the mosque of Jabal Says⁵, early 700s, south east of Damascus; and the Umar Mosque at Bosra⁶.

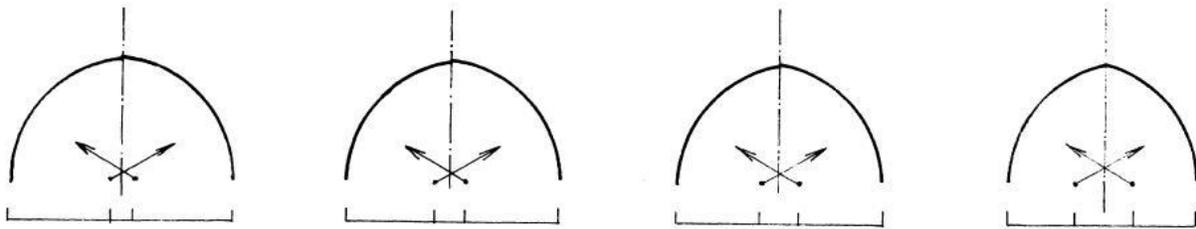


Fig. 1 Separation of the origin to form a two centre point arch. Increase in separation of the two centre points results in greater acuteness in the arch (after Warren).

The semicircular arch developed so that its centre or origin separated into two, creating the two-pointed arch (see Fig. 1). The two-pointed arch makes its first appearances in the Islamic world under the Umayyad dynasty with examples found at Qusayr Amra⁷, 712-15, and at the caldarium of the bath at Hammam as-Sarakh⁸, 725-30, identifying Syria as the place of origin of the pointed arch in Islamic architecture⁹. According to Creswell, there were no prior examples of the pointed arch, which did not make an appearance in European architecture till round about the start of the twelfth century; showing that this was an entirely Islamic development¹⁰. However, as early as the Babylonian period, there have been examples of the pointed arch in the region of

³ John Warren, *op.cit.*, p. 59

⁴ K.A.C. Creswell, *Early Muslim Architecture*, New York: Hacker Art Books, 1979, vol. 1.2, p. 387

⁵ *Ibid.* p. 474

⁶ *Ibid.* p. 545

⁷ *Ibid.* p. 391

⁸ *Ibid.* p. 442

⁹ *Ibid.* p. 443

¹⁰ K.A.C. Creswell, *Early Muslim Architecture*, vol. 1.2, *op.cit.*, pp. 442

Khorsabad¹¹. Creswell's error is due to his acceptance of how Herzfeld "had avowed that all Sasanian arches were rounded"¹², without carrying out further investigation.

In the two centuries after the introduction of the two-pointed arch in Islamic architecture, the form started developing to give the three, four and five-pointed arches. These designs were produced by moving the arrangement of the centre points onto two horizontal layers with a vertical difference (see Fig. 2). An increase in the number of centre points "postulates progressive acuteness and complexity in the curves. Their visual qualities become a stylistic feature which evolves and hence is a factor of time. It is also circumstantial and therefore indicates both date and origin."¹³ Furthermore, there are many variations of each of pointed or multiple pointed arches, where they are more or less pointed or acute. In other words, the slope of the pointed arch varies. This is achieved by increasing or decreasing the separation between the centre points (see Fig. 1).¹⁴ Two examples of arches with varied acuteness are: at the Ibn Tulun mosque, 870-9, where they are short pointed arches¹⁵, and at the Fatimid mosque of al-Hakim (al-Anwar), 990-1013, where they are high pointed arches¹⁶.

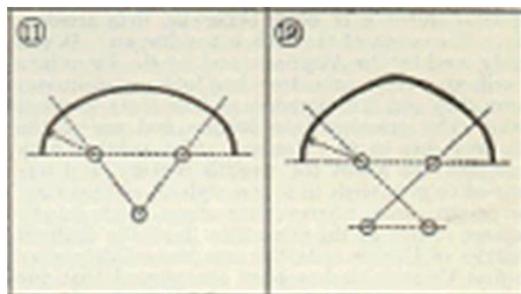


Fig. 2 Design of the three pointed, left, and four pointed arches, right (after Poole).

¹¹ Camilla Edwards & David Edwards, "The Evolution of the Shouldered Arch in Medieval Islamic Architecture", in *Architectural History*, no 42 (1999), p. 71

¹² John Warren, *op.cit.*, p. 62

¹³ *Ibid*, pp. 59-60

¹⁴ K.A.C. Creswell, *Early Muslim Architecture*, vol. 1.2, *op.cit.*, pp. 443-4

¹⁵ Doris Behrens-Abouseif, *Islamic Architecture in Cairo: An introduction*, Cairo: The American University in Cairo Press (1989), p. 63

¹⁶ *Idem*.

According to Edwards & Edwards the origins of the tri-lobed arch can be considered to lie in the pointed arch, with “cusping at the haunches”¹⁷. This possible development can be pictured more clearly if we look at the squinch of the interior dome of Masjid-I Jami at Ardistan¹⁸, 1180¹⁹, where we see that within the typical squinch that has a pointed arch outline, lies another arch cusped to form the tri-lobed arch (see Fig. 3). Therefore, it can be inferred that Iranian and Mesopotamian domes have influenced the creation of the tri-lobed arch.²⁰ Hence it is not surprising that the tri-lobed arch started developing in the area of Iran and Iraq. Variations of the tri-lobed arch include the exaggerated tri-lobed arch, which has an elongated apex (see Fig. 4.2A); the flattened tri-lobed, which has a flattened apex, or segment (see Fig. 4.2B); and the tri-lobed arch with notch shoulders²¹ (see Fig. 4.2D). In turn, the tri-lobed arched, particularly in a squinch, influenced the development of muqarnas.

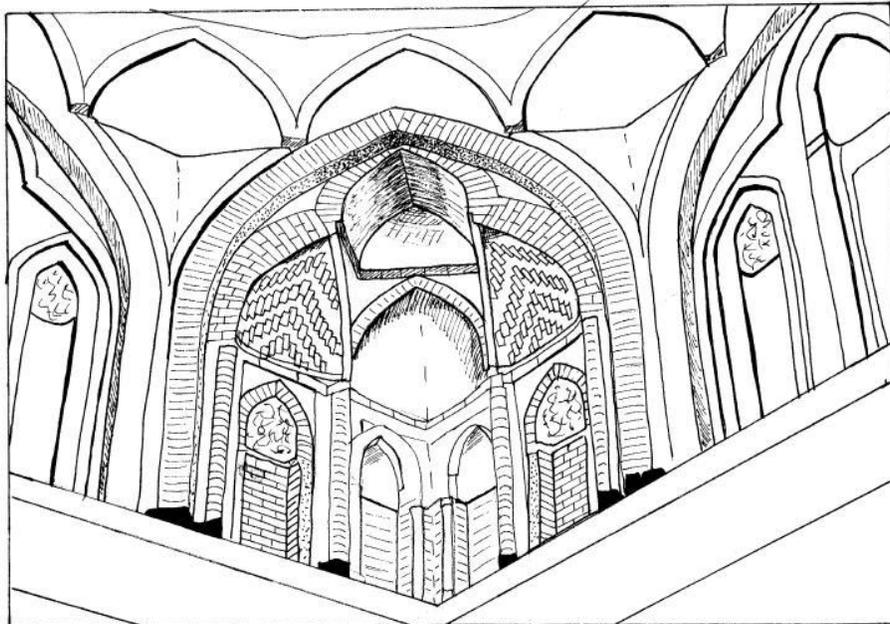


Fig. 3 Squinch with embedded tri-lobed arch at Masjid-I Jami, Ardistan (after Edwards & Edwards).

¹⁷ Camilla Edwards & David Edwards, *op.cit.*, p. 75

¹⁸ *Ibid.* p. 72

¹⁹ Arthur Pope, *Persian Architecture*, London: Oxford University Press (1969), p.58

²⁰ Camilla Edwards & David Edwards, *op.cit.*, p. 72

²¹ *Ibid.*, p. 70

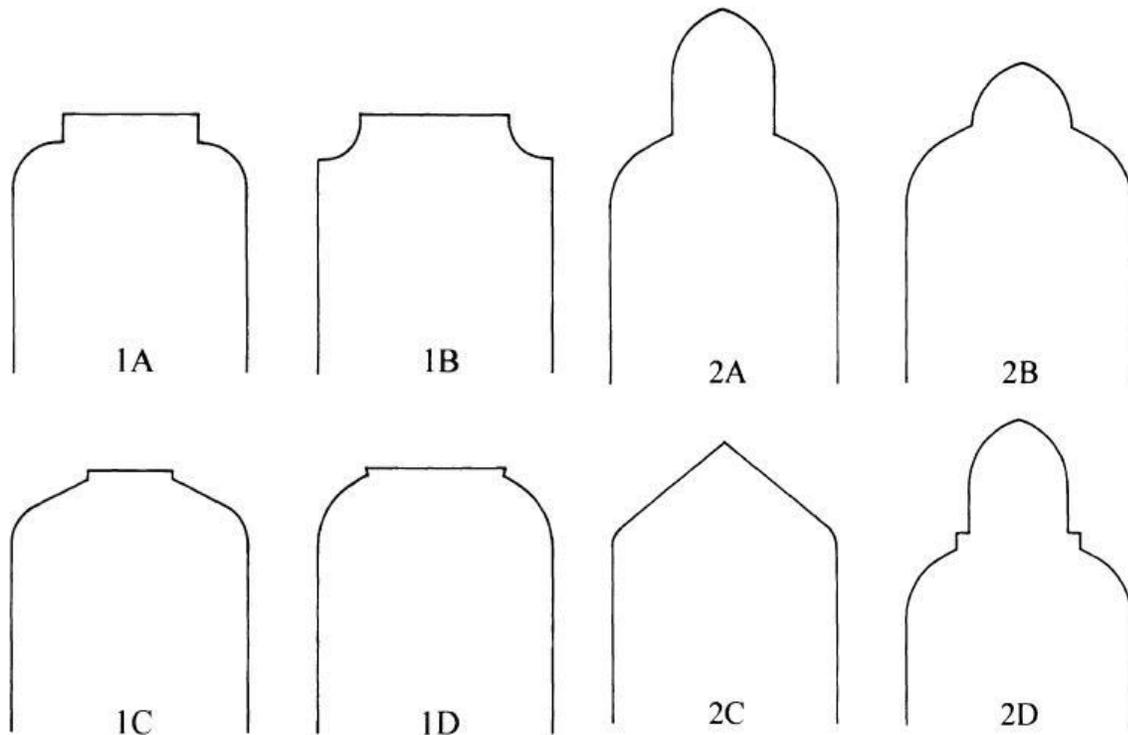


Fig. 4 Selection of corbelled shouldered arches, series 1, and selection of tri-lobed arches and a keel arch, series 2, (after Edwards & Edwards).

However, Edwards & Edwards also acknowledge that the tri-lobed arch has also been greatly influenced by the shouldered arch (see Fig. 4.1A-D). An example of the corbelled shouldered arch can be found at Zafaraniyya²² (see Fig. 5). “By the early Saljuq period (c. 1040-1100) we see the corbelled shouldered arch almost invariably associated with the tri-lobed shouldered arch in a variety of arrangements, part-structural and part-decorative.”²³ It became commonly used in the area of Iran and Iraq; no doubt it was also the reason why the tri-lobed arch was also popular in the region. Nevertheless the corbelled shouldered arch continued to be used in Seljuk architecture without the tri-lobe variant, such as in the Seljuk phase of the Isfahan Friday Mosque.

²² Camilla Edwards & David Edwards, *op.cit.*, p. 71

²³ *Ibid*, p. 75

The origins of the keel arch (see Fig. 4.2C) also known as the triangular arch, not to be confused with the quasi-four-centred arch or four-pointed arch (see Fig. 2), are not as obvious as the previous examples of arches. The keel arch can be identified for its “straight haunches”, as opposed to curved haunches of the pointed arch²⁴. Edwards & Edwards suggest that the keel arch is a development of the shouldered arch just like the tri-lobed arch, as a result of having included it in their article concentrating on the evolution of the shouldered arch. However, round about the period when the keel arch started to become common, the arts were flourishing within the Islamic Empire, many things were being created, so it should not be ruled out that the keel arch is an abstraction of the pointed arch. The keel arch became popular during the Fatimid and Ayyubid²⁵ dynasties, making appearances at Mashhad al-Juyushi (of Badr al-Gamali), 1085²⁶; the mosque of the Vizier al-Salih Tala’i’ (see Fig. 6), 1160²⁷; and at the madrasa of al-Salih Najm al-Din Ayyub, 1243²⁸. The foundation dates correlate to the theory of the evolution of the arches, the keel arches being more complex to draw or design than those previously encountered.

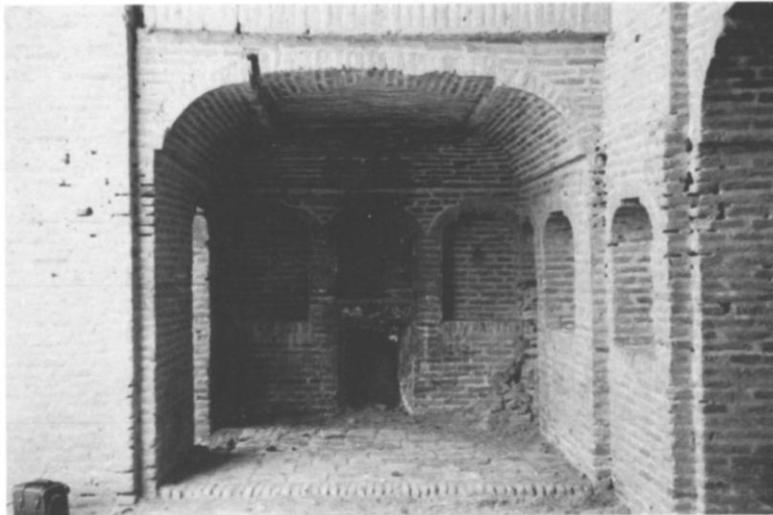


Fig. 5 Corbelled shouldered arch at the caravanserai of Zafaraniyya (after Gye).

²⁴ Camilla Edwards & David Edwards, *op.cit.*, p. 70

²⁵ *Ibid*, p. 84

²⁶ Doris Behrens-Abouseif, *op.cit.*, p. 67

²⁷ *Ibid*, pp. 76-7

²⁸ *Ibid*, p. 89



Fig. 6 Entrance façade, with keel arches, of the mosque of the Vizier al-Salih Tala'i' (Source: http://archnet.org/library/images/one-image.jsp?location_id=4870&image_id=113448).

Similarly it is unclear where the origin of the horse-shoe (see Fig. 7) arch lies. The first example of the horse-shoe arch in Islamic architecture is at the Great Mosque of Damascus²⁹. Creswell examined the topic and came across various theories pertaining to the origins of the horse-shoe arch. He discovered that Dieulafoy believed it to have been derived from Persia having found a strong correlation between the horse shoe arch and the arches at the palace of Firuzabad, 226, in the way they were constructed³⁰. On the other hand, Brown suggested that it “was the legitimate offspring of the Romanesque”³¹ arch, while Gomez-Moreno and Rivoira believed the horse-shoe arch to be derived from India³². However, the arches Gomez-Moreno and Rivoira used as reference in India were mostly found in Chaitya Halls, they were cut from stone rather than built. Such examples are the Lomas Rishi (see Fig. 8), 257 BC, or the temple at Nasik, 50 BC³³. Built examples include those found in Christian Mesopotamia, namely the

²⁹ K.A.C. Creswell, *Early Muslim Architecture*, vol. 1.2, *op.cit.*, p. 173

³⁰ *Ibid*, p. 198

³¹ *Ibid*, pp. 198-9

³² *Ibid*, p. 199

³³ *Idem*.

Baptistry of Mar Yaqub, 359, at Nasibin³⁴; in Hama, North Syria there is the Halban doorway dating from 543³⁵; the doorway of Shaykh Ali Kasun in Syria³⁶; at the apse of the church in Dana, 483³⁷; and at the apse of the church of the west monastery at Dayr Siman, 6th century³⁸.

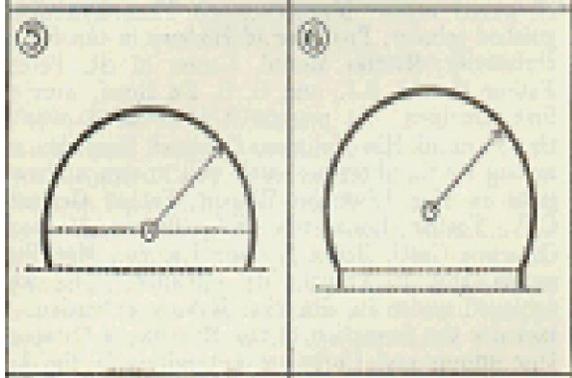


Fig. 7 Horse-shoe arch, left, and the stilted horse-shoe arch, right (after Poole).

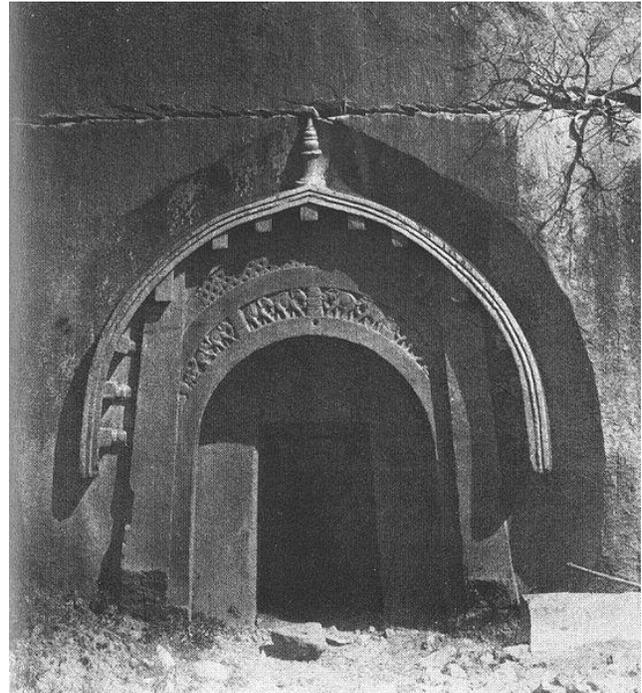


Fig. 8 Lomas Rishi (source: <http://en.wikipedia.org/wiki/File:CunninghamMauryan.jpg>).

It is very likely that the horse-shoe arches in the Great Mosque of Damascus were influenced by the churches in Syria. However, it can well be that Dieulafoy, Brown, Gomez-Moreno and Rivoira are all correct. If we assume that this is the case, then the horse-shoe arch could have originated in India. Around the time of the construction of Lomas Rishi and the temple at Nasik, the Parthian Empire spanned to the borders of India. The Parthian empire which was quite influential could have hired Indian artisans or had Indian prisoners of war which could

³⁴ K.A.C. Creswell, *Early Muslim Architecture*, vol. 1.2, *op.cit.*, p. 199

³⁵ *Idem.*

³⁶ *Ibid*, p. 200

³⁷ *Idem.*

³⁸ *Idem.*

have brought the influence of the early horse-shoe arch into central Asia. This influence could have been passed into the construction of the Firuzabad palace and the Christian Mesopotamian baptistery. Having already shown influence in a Christian place of worship, it could have easily influenced neighbouring churches such as those in Syria, which was under Byzantine rule by the time the Parthian Empire had given way to the Sassanian Empire. Romanesque architecture is a combination of Roman and Byzantine architecture; therefore, Romanesque architecture could have picked up on the influence of Byzantine Syria. Therefore, if this is correct, then all four theories as to the origin of the horse-shoe arch are correct.

However, this does not explain how it evolved within the Islamic Empire. There is a large time period, approximately two centuries, between the construction of the Great Mosque of Damascus and the construction of other monuments where the horse-shoe arch becomes popular, mostly under the Aghlabid and Spanish Umayyad dynasties. In a way this raises the question of whether the popular Islamic horse-shoe arch was a direct influence of a previous form or if it was genuinely derived afresh by abstracting the semicircular arch. The semicircular arch could have been abstracted to create the horse-shoe arch by slightly vertically, from the point of origin of the circle, raising the circle that creates the semicircular outline form of the arch.

There is an obvious evolution in the arch when it comes to its shape, but it also evolves in its purpose in a building. Often the evolution of the shape is affected by its structural purpose in the building. Arches function in a structural manner by helping to support the weight of the building above an opening, to prevent that section from collapsing due to a lack of support. Therefore, an arch is placed across an opening to distribute the weight of the building above it so that it can maintain its shape without collapsing. The stones or bricks of the arches do not fall as they are cut, shaped or arranged in a manner that supports all the other stones or bricks,

preventing them from falling. Mortar is used to help reinforce this, keeping all units aligned so that they do not shift weakening the arch as a whole.

“For an arch of a given rise and span and carrying a particular configuration of loads, there is an ideal shape, called the “linear arch”.”³⁹ The form or shape of the linear arch is determined by the weight it carries so that “the linear arch represents the form which the real arch should take to carry the particular configuration of loads with maximum efficiency.”⁴⁰ The linear arch tends to have a rectangular looking curve or a pointed curve (see Fig. 9). This would greatly explain the evolution of the corbelled shouldered-arch (rectangular curve), the keel arch and the pointed arch from a structural perspective, as these would be the arches most suitable to support the weight above them. This occurs because “where an arch is loaded more heavily at its centre the linear arch will be more sharply pointed, and where the real arch has heavily loaded haunches the linear arch will be flat-topped.”⁴¹

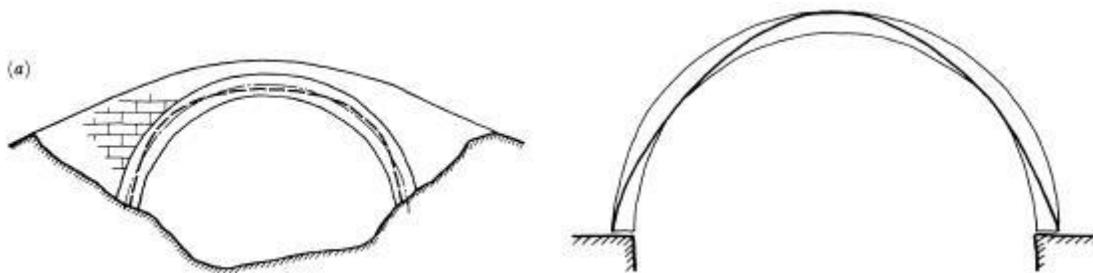


Fig. 9 Linear arches. Rectangular curve, left. Pointed curve, right. (after Gye).

It is not certain whether or not the architects or masons were aware of stability as a result of the linear arch. If they were, then it was probably knowledge derived from observation, in a sort of trial and error process, rather than mathematical calculations although the second option should not be ruled out. However, it seems unlikely that they knew of the linear arch form

³⁹ D.H. Gye, *Arches and Domes in Iranian Islamic Buildings: An engineer's perspective*. Iran: Journal of the British Institute of Persian Studies, no 26 (1988), p. 134

⁴⁰ *Idem*.

⁴¹ *Ibid*, p. 136

through mathematical calculations because if the linear arch's shape does not lie within the actual arch, but is not too far off then the arch must be constructed to be thick in order to properly support its load without the risk of a collapse. Yet there is no consistent evidence that shows that the closer arches were in form to the linear arch, the thinner they were as they did not need to be as thick, which would have saved money on masonry.

Sometimes, what caused the collapse of arches was not an incorrect form, but the stones or bricks that made up the voussoir of the arch were laid incorrectly, resulting in tension, making the arch unstable. Arches are strong against compression and sliding, but not against tension⁴².

It can appear that:

“that tall arches are more stable than flat ones. That is in fact only half true. Although a flat arch gives rise to large abutment thrusts, it can carry a much larger range of loads than a tall arch, while still containing the linear arches safely within its thickness. Taking the flat arch to its ultimate, the lintel or plate-bande, it can in theory withstand any range of loading whatsoever. However, the thrust at the abutments (and also within the masonry of the lintel, though this does not matter) can become very high and abutment movement will therefore be difficult to prevent. The flat arch is, also, simply on account of geometry, very sensitive to abutment movement; the smallest displacement can result in substantial sagging”⁴³ (see Fig. 10).

⁴² D.H. Gye, *op.cit.*, p. 131

⁴³ *Ibid*, pp. 138-9

Sagging would cause tension which could lead to a collapse. There is a correlation between this and how there is a larger amount of arches in Islamic architecture that have a pointed linear arch than a rectangular linear arch.

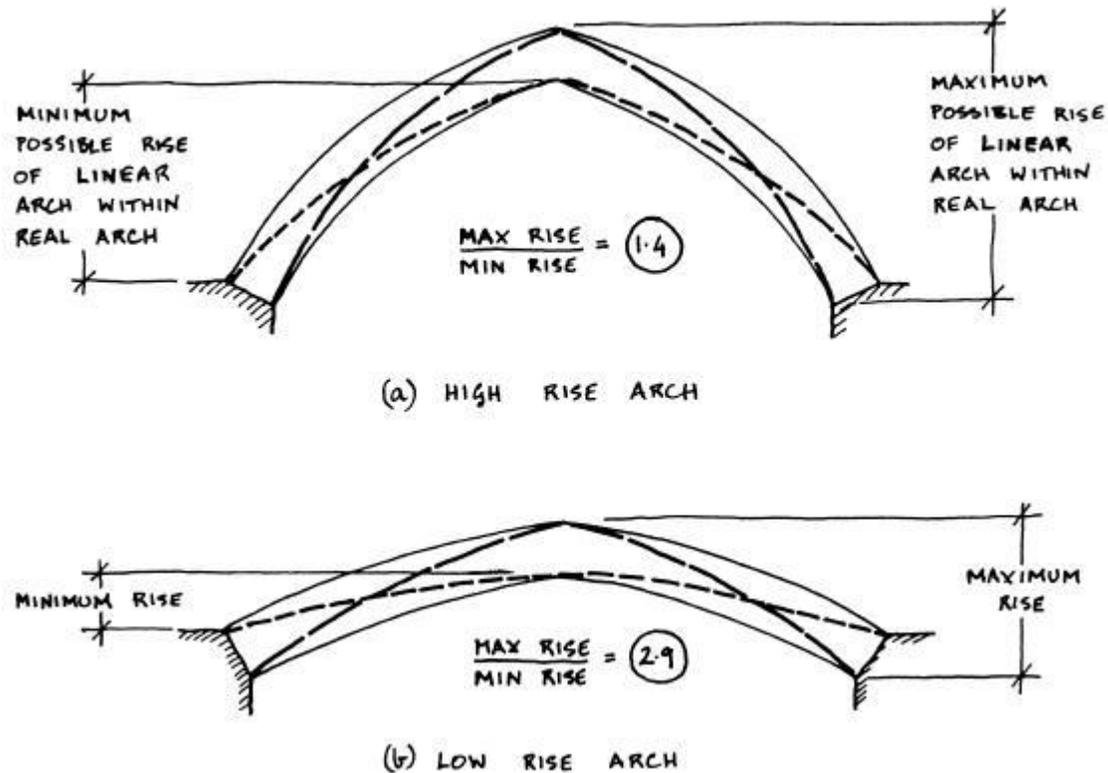


Fig. 10 High rise arch can withstand a smaller load than a low rise arch (after Gye).

It is slightly odd that pointed arches are a lot more common than the rare Islamic parabolic arches when “for a perfectly uniform load, a rare occurrence in practice, the linear arch is parabolic”⁴⁴ (see Fig. 11). However, this might explain why structurally the shouldered and pointed arch developed into the tri-lobed arch. One can see that the tri-lobed arch rough outline slightly resembles that of a parabola. As already discussed with the origins of the tri-lobed arch, it is obvious that structure took a large part in its development, through its place as a squinch in Iranian Islamic architecture, taking on an important load of the domes it supported.

⁴⁴D.H. Gye, *op.cit.*, p. 136

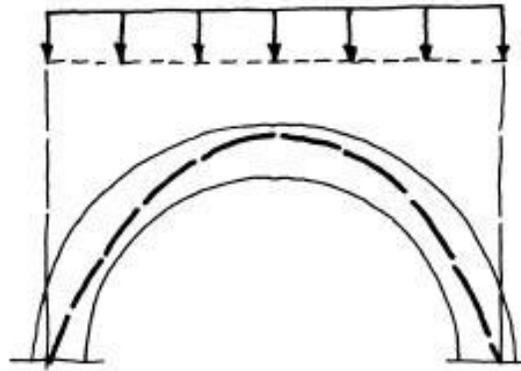


Fig. 11 Parabolic linear arch for uniform load (after Gye).

We can see that the shouldered arch developed in a structural manner with the intention of removing unsupported lintels or to allow for a wider opening without the need for longer lintels⁴⁵. Reasons why this might have been desirable include a lack of availability of materials with which to make suitable lintels, or because the desired width of the opening could not be achieved with the available lintels⁴⁶. Gye's observations showed "that in the corbelled shouldered-arch form this device can withstand a wide range of loading; it is significant that the device is used regularly for vaulting in caravanserais, e.g. at Zafaraniyya"⁴⁷ (see Fig. 10), which explains why an arch would be preferable to a lintel or wooden beam. Furthermore, in a large expensive structure, such as a fort, it would save space and hence money to keep the apex height as low as possible using the shouldered arch without having to import large amounts of wood⁴⁸.

When structural considerations are taken into account, corbelled shouldered-arches are preferably used in small openings where the central stone or timber lintel of the arch can be small and therefore easily obtained. For this reason it is rare to find large arches that are

⁴⁵ D.H. Gye, *op.cit.*, p. 71

⁴⁶ Camilla Edwards & David Edwards, *op.cit.*, p. 71

⁴⁷ *Idem.*

⁴⁸ *Idem.*

corbelled shouldered-arches, especially if they are made from brick, even though this is not the case at Zafaraniyya where the large corbelled shouldered arches are made from brick⁴⁹.

It is often common to see tie-beams or tie-bars connecting arches, particularly in mosques, to decrease the thrust at the abutments⁵⁰. However, the majority are used in riwaq style arcades, where the tie-beams are not required⁵¹.

Arches are constructed from either brick or stone. Usually the eastern end of the Islamic Empire uses bricks to construct its arches, while the western end uses stone and the middle section uses both depending on the nearness of stone quarries.

The general usage of one particular in the construction of arches contributed to which method of construction is mostly used in which region of the empire. The first method consists of raising two permanent centerings of reinforced mortar. Then bricks are laid vertically between the two guides⁵² (see Fig. 12). It is a method that unsurprisingly is used in the eastern end of the empire more than the western end. The second method consists of a wooden centering that is temporarily placed over the jambs. It is then layered with mortar reinforced with small stones. Then a ring of voussoir is layered around it⁵³ (see Fig. 13). This technique is commonly used with both bricks and stones.

It has become apparent that within the Islamic Empire arches have evolved through time and geography. Having started out quite simple as the semicircular arch, it evolved splitting its centre to form the two-pointed arch which led to the multiple centre arches, the keel arch and the tri-lobed arch, becoming more complex with the passing of time. Even though, the tri-lobed arch was likely to have developed as a result of the joint influences of the pointed arch and the

⁴⁹ Camilla Edwards & David Edwards, *op.cit.*, p. 71

⁵⁰ D.H. Gye, *op.cit.*, p. 139

⁵¹ *Idem.*

⁵² K.A.C. Creswell, *Early Muslim Architecture*, New York: Hacker Art Books, 1979, vol. 2, p. 61

⁵³ *Ibid*, p.63

corbelled shouldered arch. Furthermore, although the origins of the horse-shoe arch in Islamic architecture are not certain, it is quite possible that it has been influenced by Indian, Christian Mesopotamian and Romanesque architecture.

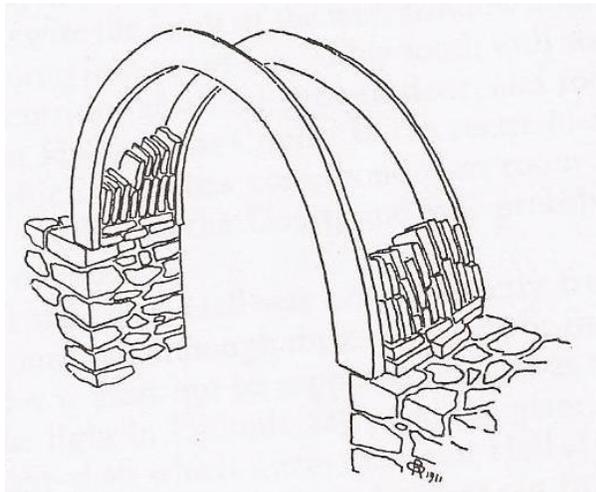


Fig. 12 First method of construction (after Creswell).

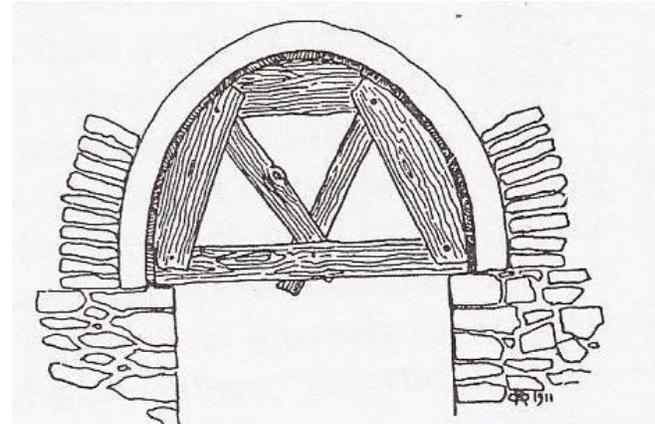


Fig. 13 Second method of construction (after Creswell).

Arches have also evolved by regions, where pre-1250, the stone pointed and horse-shoe arches became popular in the west of Dar al-Islam, whereas the brick pointed, tri-lobed and corbelled shouldered arch became popular in the east of Dar al-Islam, even though there appears to be no particular reason for this.

Having looked at the structure of the arches, it has become evident that this evolution in the form of arches took place not just for aesthetic reasons, but also for structural reasons. Even though, the evolution of the arch for structural reasons went hand-in-hand with its aesthetic evolution. However, as mentioned, structurally the arches might have developed in this fashion as a result of trial and error, where arches close in shape to the linear arch withstood their load and did not collapse. With the result that arches with a form that lied along the linear arch were

the most stable: the pointed arch, the corbelled shouldered arch and a parabolic arch. Which can also include the keel, tri-lobed and horse-shoe arches as their form generally lies along the pointed and parabolic linear arches. It is therefore, not surprising that having evolved into these forms, these arches were the most prominent arches within the Islamic Empire by 1250.

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