Islamic geometric patterns

Islamic decoration , which tends to avoid using figurative images , makes frequent use of geometric patterns which have developed over the centuries .

The geometric designs in Islamic art are often built on combinations of repeated squares and circles , which may be overlapped and interlaced , as can arabesques (with which they are often combined) , to form intricate and complex patterns , including a wide variety of tessellations . These may constitute the entire decoration , may form a framework for floral or calligraphic embellishments , or may retreat into the background around other motifs . The complexity and variety of patterns used evolved from simple stars and lozenges in the ninth century , through a variety of 6- to 13 @-@ point patterns by the 13th century , and finally to include also 14- and 16 @-@ point stars in the sixteenth century .

Geometric patterns occur in a variety of forms in Islamic art and architecture including kilim carpets , Persian girih and Moroccan zellige tilework , muqarnas decorative vaulting , jali pierced stone screens , ceramics , leather , stained glass , woodwork , and metalwork .

Interest in Islamic geometric patterns is increasing in the West , both among craftsmen and artists including M. C. Escher in the twentieth century , and among mathematicians and physicists including Peter J. Lu and Paul Steinhardt who controversially claimed in 2007 that tilings at the Darb @-@ e Imam shrine in Isfahan could generate quasi @-@ periodic patterns like Penrose tilings .

Background

Islamic decoration

Islamic art mostly avoids figurative images to avoid becoming objects of worship . Islamic geometric patterns derived from simpler designs used in earlier cultures : Greek , Roman , and Sasanian . They are one of three forms of Islamic decoration , the others being the arabesque based on curving and branching plant forms , and Islamic calligraphy ; all three are frequently used together . Geometric designs and arabesques are forms of Islamic interlace patterns .

Purpose

Authors such as Keith Critchlow argue that Islamic patterns are created to lead the viewer to an understanding of the underlying reality , rather than being mere decoration , as writers interested only in pattern sometimes imply . David Wade states that " Much of the art of Islam , whether in architecture , ceramics , textiles or books , is the art of decoration ? which is to say , of transformation . " Wade argues that the aim is to transfigure , turning mosques " into lightness and pattern " , while " the decorated pages of a Qur ? an can become windows onto the infinite . " Against this , Doris Behrens @-@ Abouseif states in her book Beauty in Arabic Culture that a " major difference " between the philosophical thinking of Medieval Europe and the Islamic world is exactly that the concepts of the good and the beautiful are separated in Arabic culture . She argues that beauty , whether in poetry or in the visual arts , was enjoyed " for its own sake , without commitment to religious or moral criteria " .

Pattern formation

Many Islamic designs are built on squares and circles , typically repeated , overlapped and interlaced to form intricate and complex patterns . A recurring motif is the 8 @-@ pointed star , often seen in Islamic tilework ; it is made of two squares , one rotated 45 degrees with respect to the other . The fourth basic shape is the polygon , including pentagons and octagons . All of these can be combined and reworked to form complicated patterns with a variety of symmetries including reflections and rotations . Such patterns can be seen as mathematical tessellations , which can

extend indefinitely and thus suggest infinity . They are constructed on grids that require only ruler and compasses to draw . Artist and educator Roman Verostko argues that such constructions are in effect algorithms , making Islamic geometric patterns forerunners of modern algorithmic art .

The circle symbolizes unity and diversity in nature , and many Islamic patterns are drawn starting with a circle . For example , the decoration of the 15th century mosque in Yazd , Iran is based on a circle , divided into six by six circles drawn around it , all touching at its centre and each touching its two neighbours ' centres to form a regular hexagon . On this basis is constructed a six @-@ pointed star surrounded by six smaller irregular hexagons to form a tessellating star pattern . This forms the basic design which is outlined in white on the wall of the mosque . That design , however , is overlaid with an intersecting tracery in blue around tiles of other colours , forming an elaborate pattern that partially conceals the original and underlying design . A similar design forms the logo of the Mohammed Ali Research Center .

One of the early Western students of Islamic patterns , Ernest Hanbury Hankin , defined a " geometrical arabesque " as a pattern formed " with the help of construction lines consisting of polygons in contact . " He observed that many different combinations of polygons can be used as long as the residual spaces between the polygons are reasonably symmetrical . For example , a grid of octagons in contact has squares (of the same side as the octagons) as the residual spaces . Every octagon is the basis for an 8 @-@ point star , as seen at Akbar 's tomb , Sikandra (1605 ? 1613) . Hankin considered the " skill of the Arabian artists in discovering suitable combinations of polygons .. almost astounding . " He further records that if a star occurs in a corner , exactly one quarter of it should be shown ; if along an edge , exactly one half of it .

The Topkap? Scroll , made in Timurid dynasty Iran in the late 15th century or beginning of the 16th century , contains 114 patterns including coloured designs for girih tilings and muqarnas quarter or semidomes .

The mathematical properties of the decorative tile and stucco patterns of the Alhambra palace in Granada , Spain have been extensively studied . Some authors have claimed on dubious grounds to have found most or all of the 17 wallpaper groups there . Moroccan geometric woodwork from the 14th to 19th centuries makes use of only 5 wallpaper groups , mainly p4mm and c2mm , with p6mm and p2mm occasionally and p4gm rarely ; it is claimed that the " Hasba " method of construction can however generate all 17 groups .

= = Evolution = =

= = = Early stage = = =

The earliest geometrical forms in Islamic art were occasional isolated geometric shapes such as 8 @-@ pointed stars and lozenges containing squares . These date from 836 in the Great Mosque of Kairouan , Tunisia , and since then have spread all across the Islamic world .

= = = Middle stage = = =

The next development , marking the middle stage of Islamic geometric pattern usage , was of 6- and 8 @-@ point stars , which appear in 879 at the Ibn Tulun Mosque , Cairo , and then became widespread .

A wider variety of patterns were used from the 11th century . Abstract 6- and 8 @-@ point shapes appear in the Tower of Kharaqan at Qazvin , Persia in 1067 , and the Al @-@ Juyushi Mosque , Egypt in 1085 , again becoming widespread from there , though 6 @-@ point patterns are rare in Turkey .

In 1086 , 7- and 10 @-@ point girih patterns (with heptagons , 5- and 6 @-@ pointed stars , triangles and irregular hexagons) appear in the Friday Mosque at Isfahan . 10 @-@ point girih became widespread in the Islamic world , except in the Spanish Al @-@ Andalus . Soon afterwards , sweeping 9- , 11- , and 13 @-@ point girih patterns were used in the Barsian Mosque , also in

Persia , in 1098 ; these , like 7 @-@ point geometrical patterns , are rarely used outside Persia and central Asia .

Finally , marking the end of the middle stage , 8- and 12 @-@ point girih rosette patterns appear in the Alaeddin Mosque at Konya , Turkey in 1220 , and in the Abbasid palace in Baghdad in 1230 , going on to become widespread across the Islamic world .

Late stage

The beginning of the late stage is marked by the use of simple 16 @-@ point patterns at the Hasan Sadaqah mausoleum in Cairo in 1321 , and in the Alhambra in Spain in 1338 ? 1390 . These patterns are rarely found outside these two regions . More elaborate combined 16 @-@ point geometrical patterns are found in the Sultan Hasan complex in Cairo in 1363 , but rarely elsewhere . Finally , 14 @-@ point patterns appear in the Jama Masjid at Fatehpur Sikri in India in 1571 ? 1596 , but in few other places .

Artforms

Several artforms in different parts of the Islamic world make use of geometric patterns . These include ceramics , girih strapwork , jali pierced stone screens , kilim rugs , leather , metalwork , muqarnas vaulting , shakaba stained glass , woodwork , and zellige tiling .

Ceramics

Ceramics lend themselves to circular motifs , whether radial or tangential . Bowls or plates can be decorated inside or out with radial stripes ; these may be partly figurative , representing stylised leaves or flower petals , while circular bands can run around a bowl or jug . Patterns of these types were employed on Islamic ceramics from the Ayyubid period , 13th century AD . Radially symmetric flowers with , say , 6 petals lend themselves to increasingly stylised geometric designs which can combine geometric simplicity with recognisably naturalistic motifs , brightly coloured glazes , and a radial composition that ideally suits circular crockery . Potters often chose patterns suited to the shape of the vessel they were making . Thus an unglazed earthenware water flask from Aleppo in the shape of a vertical circle (with handles and neck above) is decorated with a ring of moulded braiding around an Arabic inscription with a small 8 @-@ petalled flower at the centre .

Girih tilings and woodwork

Girih are elaborate interlacing patterns formed of five standardized shapes . The style is used in Persian Islamic architecture and also in decorative woodwork . Girih designs are traditionally made in different media including cut brickwork , stucco , and mosaic faience tilework . In woodwork , especially in the Safavid period , it could be applied either as lattice frames , left plain or inset with panels such as of coloured glass ; or as mosaic panels used to decorate walls and ceilings , whether sacred or secular . In architecture , girih forms decorative interlaced strapwork surfaces from the 15th century to the 20th century . Most designs are based on a partially hidden geometric grid which provides a regular array of points ; this is made into a pattern using 2- , 3- , 4- , and 6 @-@ fold rotational symmetries which can fill the plane . The visible pattern superimposed on the grid is also geometric , with 6- , 8- , 10- and 12 @-@ pointed stars and a variety of convex polygons , joined by straps which typically seem to weave over and under each other . The visible pattern does not coincide with the underlying tiling .

Jali

Jali are pierced stone screens with regularly repeating patterns . They are characteristic of Indo @-@ Islamic architecture , for example in the Mughal dynasty buildings at Fatehpur Sikri and the

Taj Mahal . The geometric designs combine polygons such as octagons and pentagons with other shapes such as 5- and 8 @-@ pointed stars . The patterns emphasized symmetries and suggested infinity by repetition . Jali functioned as windows or room dividers , providing privacy but allowing in air and light . Jali forms a prominent element of the architecture of India . The use of perforated walls has declined with modern building standards and the need for security . Modern , simplified jali walls , for example made with pre @-@ moulded clay or cement blocks , have been popularised by the architect Laurie Baker . Pierced windows in girih style are sometimes found elsewhere in the Islamic world , such as in windows of the Mosque of Ibn Tulun in Cairo .

= = = Kilim = = =

 A kilim is an Islamic flatwoven carpet (without a pile) , whether for household use or a prayer mat . The pattern is made by winding the weft threads back over the warp threads when a colour boundary is reached . This technique leaves a gap or vertical slit , so kilims are sometimes called slit @-@ woven textiles . Kilims are often decorated with geometric patterns with 2- or 4 @-@ fold mirror or rotational symmetries . Because weaving uses vertical and horizontal threads , curves are difficult to generate , and patterns are accordingly formed mainly with straight edges . Kilim patterns are often characteristic of specific regions . Kilim motifs are often symbolic as well as decorative . For example , the wolf 's mouth or wolf 's foot motif (Turkish : Kurt A?zi , Kurt ?zi) expresses the tribal weavers ' desires for protection of their families ' flocks from wolves .

= = = Leather = = =

 Islamic leather is often embossed with patterns similar to those already described . Leather book covers , starting with the Quran where figurative artwork was excluded , were decorated with a combination of kufic script , medallions and geometric patterns , typically bordered by geometric braiding .

= = = Metalwork = = =

 Metal artefacts share the same geometric designs that are used in other forms of Islamic art . However , in the view of Hamilton Gibb , the emphasis differs : geometric patterns tend to be used for borders , and if they are in the main decorative area they are most often used in combination with other motifs such as floral designs , arabesques , animal motifs , or calligraphic script . Geometric designs in Islamic metalwork can form a grid decorated with these other motifs , or they can form the background pattern .
 Even where metal objects such as bowls and dishes do not seem to have geometric decoration , still the designs , such as arabesques , are often set in octagonal compartments or arranged in concentric bands around the object . Both closed designs (which do not repeat) and open or repetitive patterns are used . Patterns such as interlaced six @-@ pointed stars were especially popular from the twelfth century . Eva Baer notes that while this design was essentially simple , it was elaborated by metalworkers into intricate patterns interlaced with arabesques , sometimes organised around further basic Islamic patterns , such as the hexagonal pattern of six overlapping circles .

= = = Muqarnas = = =

 Muqarnas are elaborately carved ceilings to semidomes , often used in mosques . They are typically made of stucco (and thus do not have a structural function) , but can also be of wood , brick , and stone . They are characteristic of Islamic architecture of the Middle Ages from Spain and Morocco in the west to Persia in the east . Architecturally they form multiple tiers of squinches , diminishing in size as they rise . They are often elaborately decorated .

= = = Stained glass = = =

Geometrically patterned stained glass is used in a variety of settings in Islamic architecture . It is found in the surviving summer residence of the Palace of Shaki Khans , Azerbaijan , constructed in 1797 . Patterns in the " shabaka " windows include 6- , 8- , and 12 @-@ point stars . These wood @-@ framed decorative windows are distinctive features of the palace 's architecture . Shabaka are still constructed the traditional way in Sheki in the 21st century . Traditions of stained glass set in wooden frames (not lead as in Europe) survive in workshops in Iran as well as Azerbaijan . Glazed windows set in stucco arranged in girih @-@ like patterns are found both in Turkey and the Arab lands ; a late example , without the traditional balance of design elements , was made in Tunisia for the International Colonial Exhibition in Amsterdam in 1883 . The old city of Sana 'a in Yemen has stained glass windows in its tall buildings .

= = = Zellige = = =

Zellige are glazed terracotta tiles set into plaster , forming colourful mosaic patterns including regular and semiregular tessellations . The tradition is characteristic of Morocco , but is also found in Moorish Spain . Zellige is used to decorate mosques , public buildings and wealthy private houses .

= = = Illustrations = = =

= = In Western culture = =

It is sometimes supposed in Western society that mistakes in repetitive Islamic patterns such as those on carpets were intentionally introduced as a show of humility by artists who believed only Allah can produce perfection , but this theory is denied .

Major Western collections hold many objects of widely varying materials with Islamic geometric patterns . The Victoria and Albert Museum in London holds at least 283 such objects , of materials including wallpaper , carved wood , inlaid wood , tin- or lead @-@ glazed earthenware , brass , stucco , glass , woven silk , ivory , and pen or pencil drawings . The Metropolitan Museum of Art in New York has among other relevant holdings 124 mediaeval (1000 ? 1400 A.D.) objects bearing Islamic geometric patterns , including a pair of Egyptian minbar (pulpit) doors almost 2 m. high in rosewood and mulberry inlaid with ivory and ebony ; and an entire mihrab (prayer niche) from Isfahan , decorated with polychrome mosaic , and weighing over 2 @,@ 000 kg .

The Dutch artist M. C. Escher was inspired by the Alhambra 's intricate decorative designs to study the mathematics of tessellation , transforming his style and influencing the rest of his artistic career . In his own words it was " the richest source of inspiration I have ever tapped . "

Cultural organisations such as the Mathematical Sciences Research Institute and the Institute for Advanced Study run events on geometric patterns and related aspects of Islamic art . In 2013 the Istanbul Center of Design and the Ensar Foundation ran what they claimed was the first ever symposium of Islamic Arts and Geometric Patterns , in Istanbul . The panel included the experts on Islamic geometric pattern Carol Bier , Jay Bonner , Eric Broug , Hacali Necefo?lu and Reza Sarhangi . In Britain , The Prince 's School of Traditional Arts runs a range of courses in Islamic art including geometry , calligraphy , and arabesque (vegetal forms) , tile @-@ making , and plaster carving .

Computer graphics and computer @-@ aided manufacturing make it possible to design and produce Islamic geometric patterns effectively and economically . Craig S. Kaplan explains and illustrates in his Ph.D. thesis how Islamic star patterns can be generated algorithmically .

Two physicists , Peter J. Lu and Paul Steinhardt , attracted controversy in 2007 by claiming that girih designs such as that used on the Darb @-@ e Imam shrine in Isfahan were able to create quasi @-@ periodic tilings resembling those discovered by Roger Penrose in 1973 . They showed that rather than the traditional ruler and compass construction , it was possible to create girih

designs using a set of five " girih tiles " , all equilateral polygons , secondarily decorated with lines (for the strapwork) .

In 2016 , Ahmad Rafsanjani described the use of Islamic geometric patterns from tomb towers in Iran to create auxetic materials from perforated rubber sheets . These are stable in either a contracted or an expanded state , and can switch between the two , which might be useful for surgical stents or for spacecraft components . When a conventional material is stretched along one axis , it contracts along other axes (at right angles to the stretch) . But auxetic materials expand at right angles to the pull . The internal structure that enables this unusual behaviour is inspired by two of the 70 Islamic patterns that Rafsanjani noted on the tomb towers .