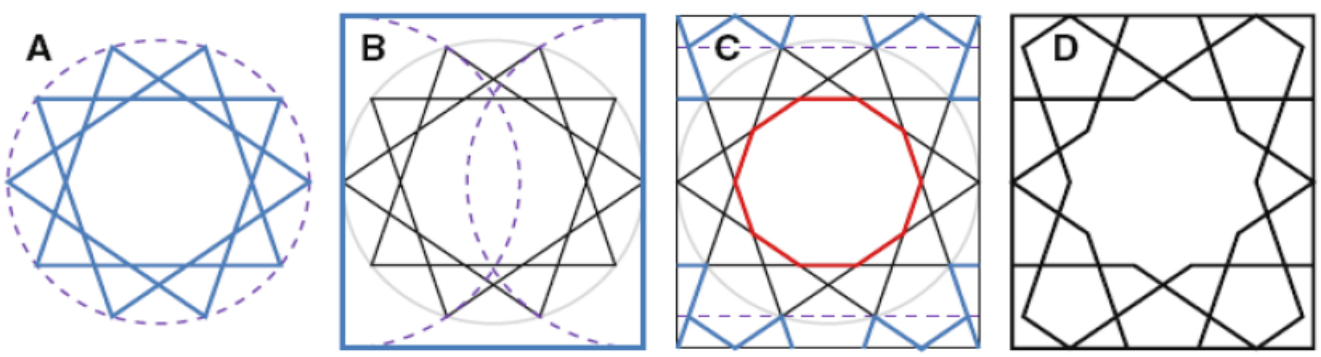
Geometry in Islamic Architecture

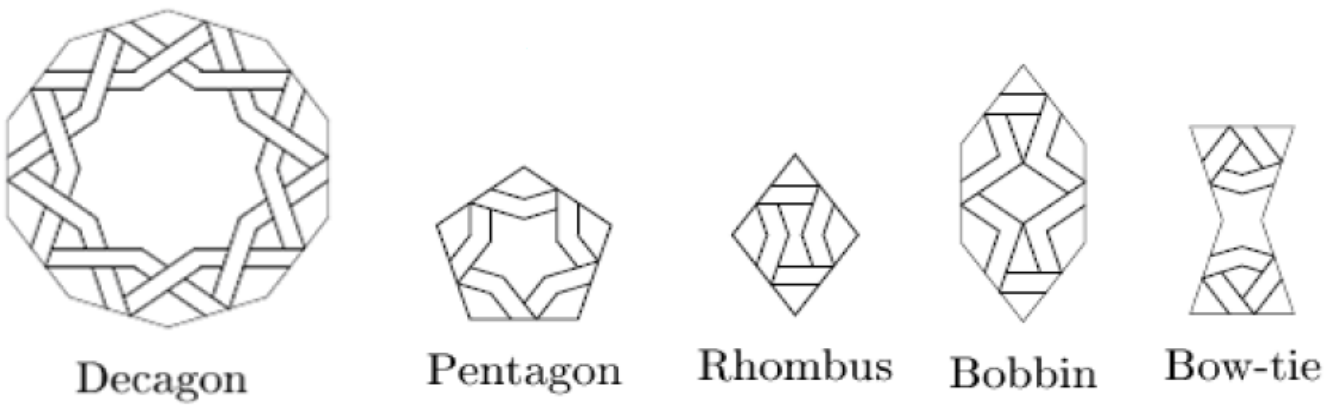
Just like rest of the advances the Muslims made, they incorporated logic into their Architecture. Islamic artists would combine geometry with traditional art to form a new art consisting of repeating patterns and corresponding shapes. The Islamic philosophers had learned about geometry by looking at the works of the Greek philosophers and mathmematicians, Euclid and Pythagoras. It was first thought off by reserachers that the Muslims were able to create tilings by direct strapwork method. This would mean that mathematicians would have to construct an entire tiling with only utilizing a straighedge and compass. Later it was was later found out that this long process would be potentially impossible considering the error-less and complex patterns there were.

Direct Strapwork Method



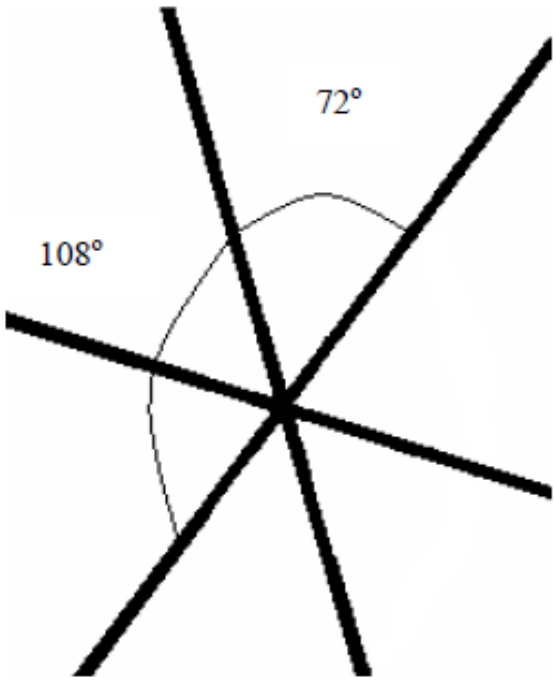
By 1200 C.E. there was an important breakthrough in Islamic mathematics and design which was the discovery of a new way to construct girih line patterns as decorated tessellations (A tessellation is created when a shape is repeated over and over again covering a plane without any gaps or overlaps) using a set of five tile types, which are called "girih tiles." Girih tiles are a set of five tiles that are used for creating tiling patterns for the decoration of buildings.

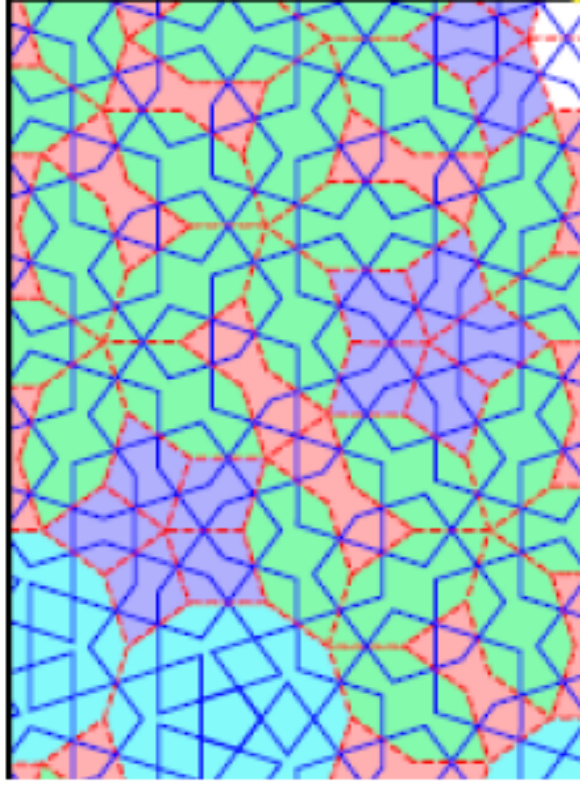
Girih Tiling



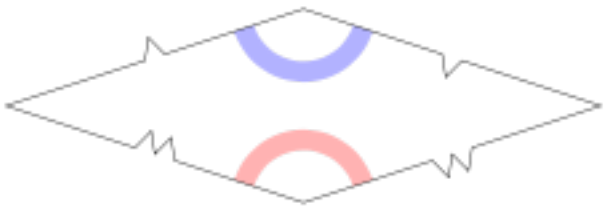
- a regular decagon with ten interior angles of 144°;
- an elongated (irregular convex) hexagon with interior angles of 72°, 144°, 144°, 72°, 144°, 144°;
- a bow tie (non-convex hexagon) with interior angles of 72°, 72°, 216°, 72°, 72°, 216°;
- a rhombus with interior angles of 72°, 108°, 72°, 108°; and
- a regular pentagon with five interior angles of 108°.

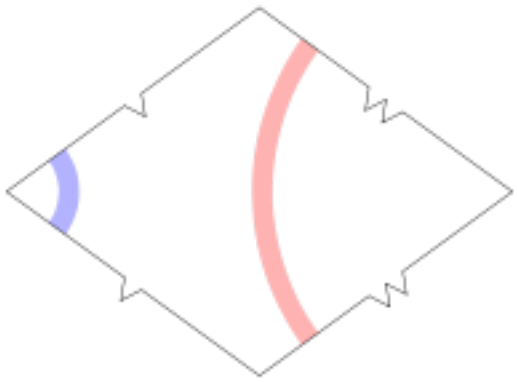
In girih tiling the edge of each of the five tiles are the same length. The girih tiles also have decorating lines incorporated into them and each of these decorating lines intersect the mid-point of every edge at 72 and 108 degreed angles. These decorative lines allow a continuous pattern to form across an entire tiling.

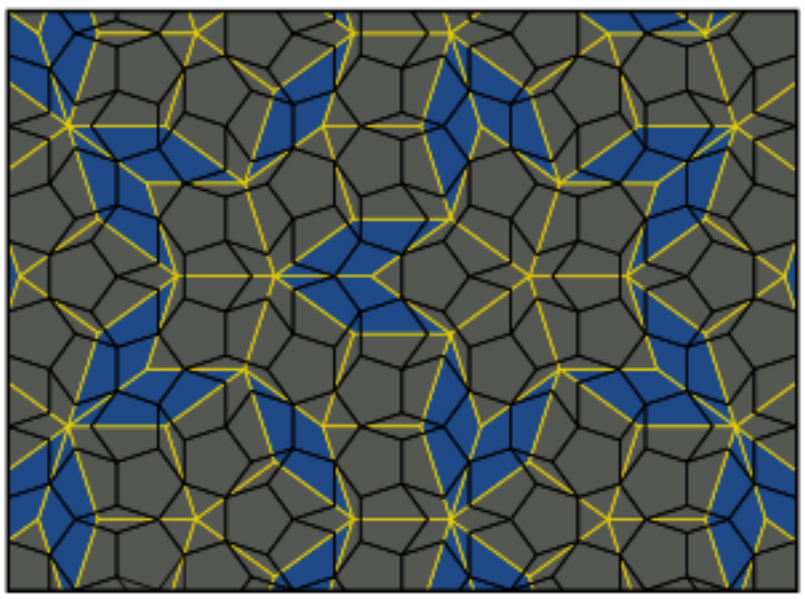




The method of using girih tiles to make tiled patterns allowed for the penrose pattern to be utilized within the grids. This penrose pattern would later be combined with self-similar transformations to construct a quasi-periodic, Penrose pattern. Penrose tiling is an aperiodic tiling with no translational symmetry, both meaning the patterns never repeat themselves exactly. There are two different sets of patterns that can be used in Penrose tiling. The first set consists of two different kinds of rhombuses.

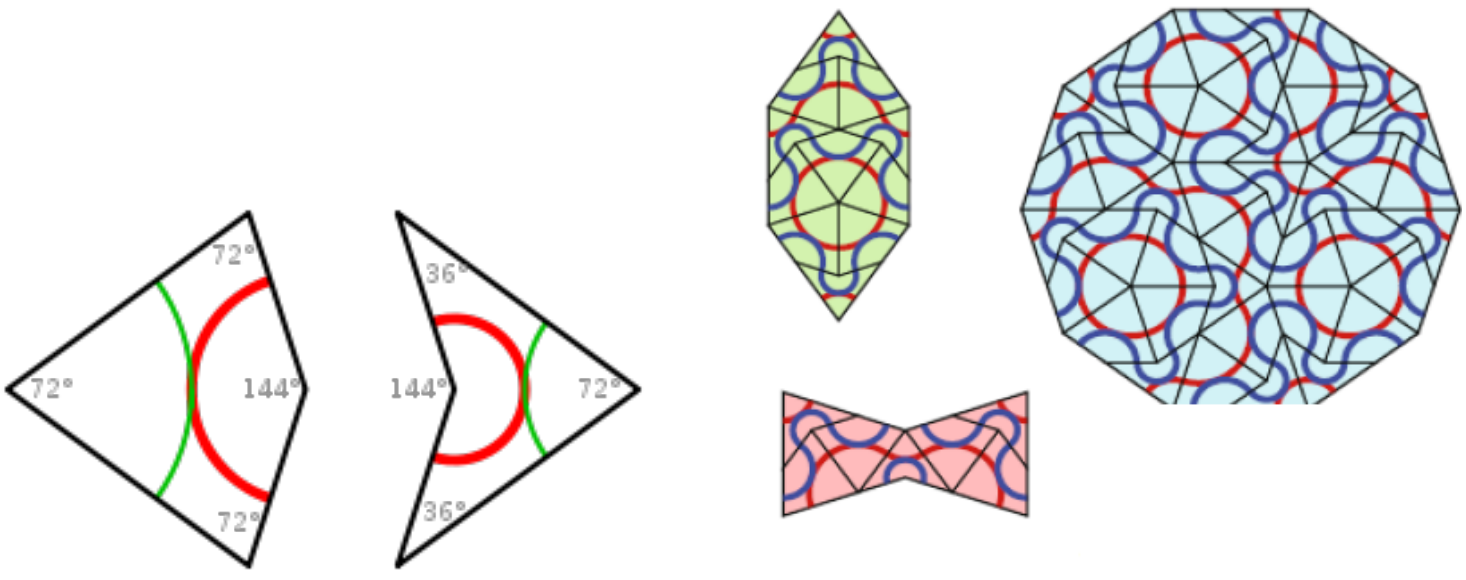






- The thin rhombus **t** has four corners with angles of 36, 144, 36, and 144 degrees. The **t** rhombus may be bisected along its short diagonal to form a pair of acute Robinson triangles.
- The thick rhombus **T** has angles of 72, 108, 72, and 108 degrees. The **T** rhombus may be bisected along its long diagonal to form a pair of obtuse Robinson triangles

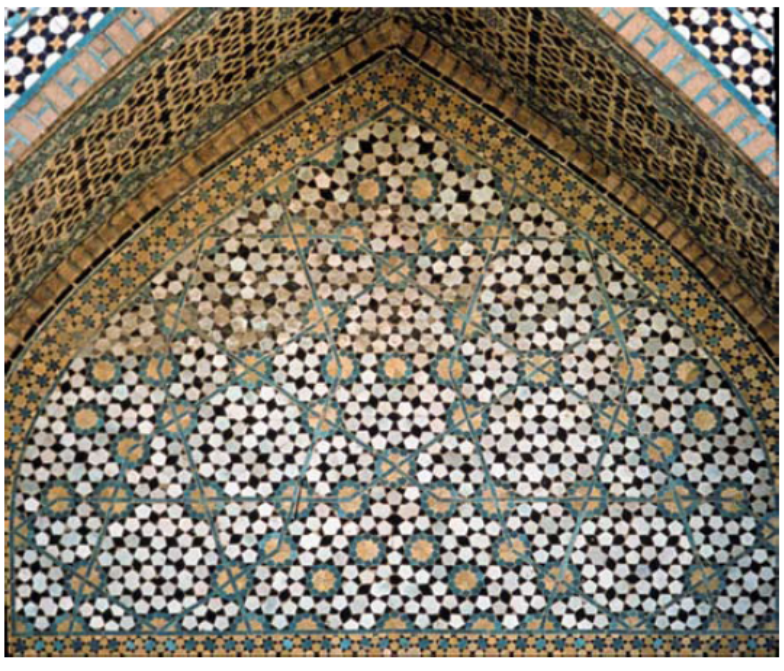
The second set consists of a four sided kite and dart. This technique was most popular in Islamic architecture.

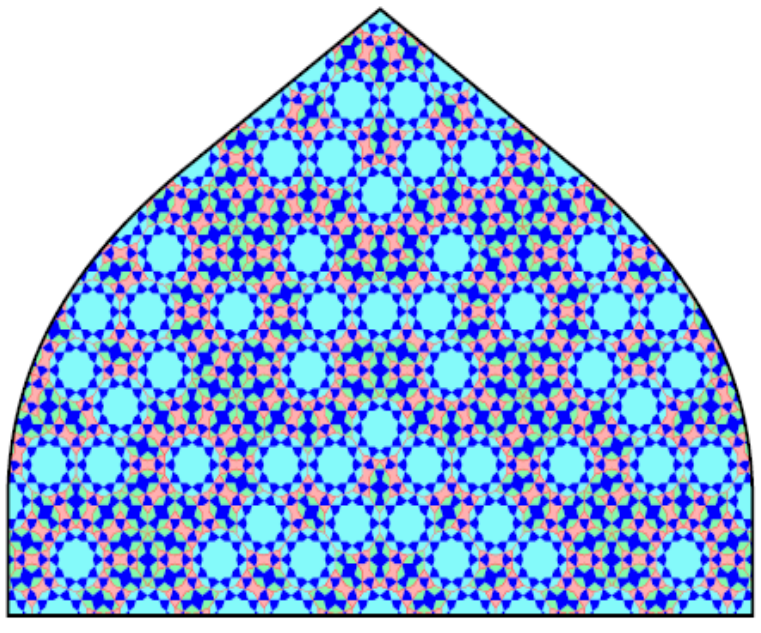


- The **Kite** is a quadrilateral whose four corners have angles of 72, 72, 72, and 144 degrees. The Kite may be bisected along its axis of symmetry to form a pair of acute Robinson triangles.
- The **Dart** is a non-convex quadrilateral whose four interior angles are 36, 72, 36, and 216 degrees. The Dart may be bisected along its axis of symmetry to form a pair of obtuse Robinson triangles

There are two different kinds of applications to describe the repeating patterns in portrayed in Islamic art. The Islamic artists went ahead and produced "quasi-periodic" patterns long before that concept was born in the Western world. A quasi-periodic tiling is when the pattern is extended to infinite proportions, so that copies of any finite portion can be found evenly distributed throughout the tiling. The application of self-similarity transformation can also be seen. It occurs when the overlapping patterns at two different length scales (the subdivision of large girih tiles into smaller ones) is seen in one tiling. These Islamic designs might have been something of shapes or decoration, but when looked at closely the complexity of the use of geometry in the designs really brings out Islamic Architecture in it's Golden Age.

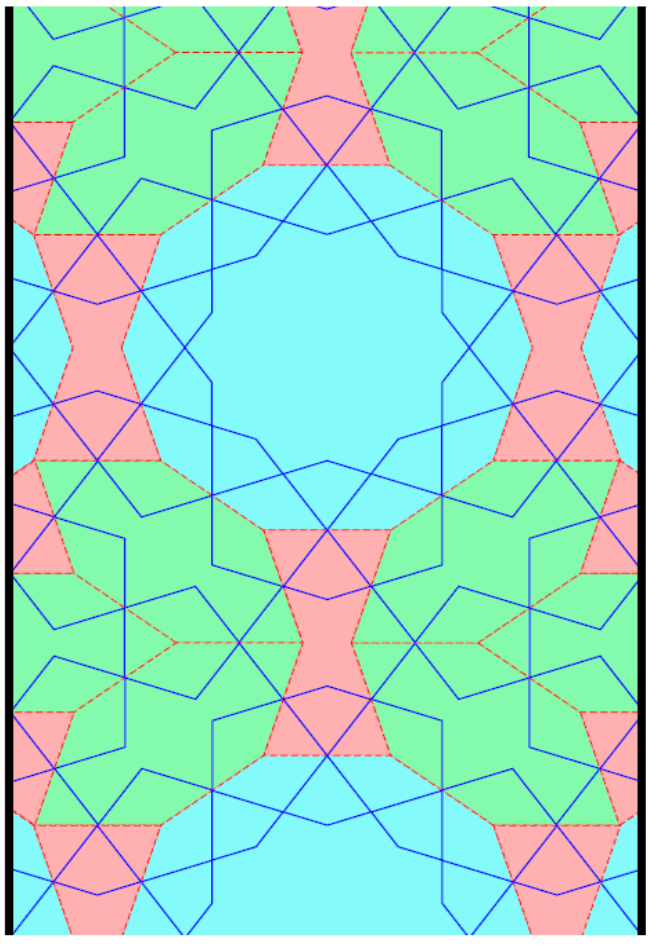
Quasi-Periodic Tiling





Portal from the Darb-i Imam Shrine at Isfahan, Iran (1453 AD)

Self-Similarity Transformation

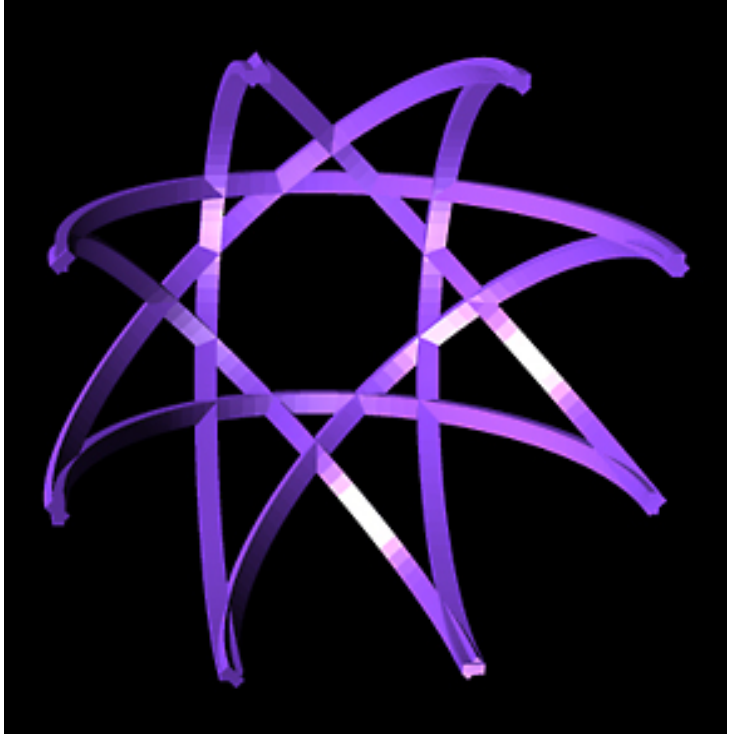


Interior archway at the opening of the Sultan’s Lodge in the Ottoman Green Mosque in Bursa, Turkey (1424 AD)

Back to Reality

Geometric motifs were popular with Muslim artists and designers in all parts of the world, at all times, and for decorating every surface, whether walls or floors, pots or lamps, book covers or textiles. Geometric motifs weren't the only art and architecture that incorporated math. The domes of many famous architectural buildings like The Mezquita or the Dome of the Rock, both consisted of domes that were created by studying the laws of geometry. By the 10th century ribbed domes were popularly used in the domes in typical Islamic architecture. Instead of creating domes by rotating ribs so that they all reached the middle, highest point of the dome (apex), the Muslims created a new and more efficient way to build arches. The Muslims took pairs of arches instead and started rotating them so that the end result would look like an 8 pointed star. The structure of the dome now has balanced proportions and is aesthetically pleasing. This simliar architectural technique can be seen in The Mezquita or The Mosque at Corboda, Spain.

The Mezquita



The star ribbed domes eventually progressed until there could be up to 12, 16, 24, 32, 48, or 64 rotations in one dome. The Muslims created many of their domes with the star ribbed because of its balanced proportions, dynamic appearance, and the relationship to both the circle and square at the same time.