Geometric Patterns In Islamic Architecture

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History
History

- Islam is a monotheistic and Abrahamic religion
- Islam was articulated by the Qur’an and the teachings of Muhammad (sunnah)
- Islam began in 7th century in Arabia (Mecca)
- Islamic Empire was first formed in modern Saudi Arabia and Yemen under Muhammad
- Islamic Empire rapidly expanded from 632 to 730, leaving an empire stretching from Europe to North Africa and India
- The end of the Islamic Empire is generally said to be the fall of the Ottoman Empire in 1918, when it was defeated by British and French armies during the WWI.
-Charles Martel (left, mounted on his white horse wielding an axe) defeating Abdul Rahman Al Guafiqi (right) at the battle of Poitiers (732 A.D)

-This battle/campaign determined the largest size of the Islamic Empire, because it halted its advance in Europe and carried heavy lose
Halted Advance by the Franks
Islamic Art and Architecture - Background
Characteristics of Islamic Art

- Islamic art encompasses visual arts created from 7th century onwards by people who lived within territories inhabited or ruled by Islamic populations
  - art of Islamic world reflects its values and reveals the way Muslims view the spiritual realm and universe
- No people appear in religious art (feared to be a form of idolatry, which is forbidden by the Qur’an)
- Seeks to portray the meaning and essence of things, rather than just their physical form
  - Does not want to replicate nature, but attempts to convey what it represents
  - Allows the artist and those who experience art to get closer to God
Islamic Architecture

- Principal Types of Architecture
  - Mosques
  - Tombs
  - Palaces
  - Forts

- Decoration features heavily in buildings
  - Serves as unifying factor
  - Create sense of peace and contemplation (religious buildings)

- Islamic decoration consists of three main elements
  - Calligraphy
  - Arabesques
  - Geometric Patterns
Types of Geometric Patterns

- Based on constructive polygons, such as hexagons and octagons
- Star polygons created by connecting vertices of constructive polygons
- All patterns whose main elements are from a hexagon classified as 6-point geometrical patterns, all patterns whose main elements are from an octagon classified as 8-point geometrical patterns etc.
- Rosette consists of n-sided star shape surrounded by n hexagons and n quadrilaterals
Construction of Hexagon - Example

1. Draw horizontal line using straightedge.

2. Draw circle with compass point placed near center of line. Using the intersection points as new compass points, draw a circle on either side of first circle.

3. Add four more new circles using new points of intersection as compass points (important that all circles have same radius).
Construction of Hexagon cont’d

4. To form hexagon, use a straightedge to join adjacent circumference points on central circle.
Evolution of Islamic Geometric Designs - Early Stage

- Featured naturalistic designs
  - Vegetal and floral patterns
- Some of earliest geometric designs appear in The Great Mosque of Kairouan
  - Constructed in 670 AD, rebuild in 836 AD
- Simple 6- and 8- point geometrical patterns found in Mosque of Ibn-Tulun are among earliest examples of woven geometrical patterns
  - Milestone in terms of introducing geometrical patterns to Islamic architecture
- By end of 9th century, geometric motifs commonly used by Muslim architects and artisans
Evolution of Islamic Geometric Designs - Middle Stage

- From 11th - 13th century, wider variety of patterns in use
- Development of Girih tiles

Tower of Kharaqan in Iran (1069 - 1093), 6-point and 8-point geometrical patterns

Great Mosque of Isfahan in Iran (1086), 13-point pattern

Mosque of Al-Nasir Mohammed (1318- 1334) in Egypt, 16-point geometrical pattern
Evolution of Islamic Geometric Designs - Late Stage

- Architects in Iran in 16th and 17th centuries used decorative patterns with geometric and floral motifs in both religious and secular buildings
- Mughal architecture, in India, avoided highly detailed geometric arrangements, such as 12-point and 16-point patterns
  - Instead exerted great effort into creating accurate and perfect proportions of pattern shapes and angles

Ali-Qapu Palace (1598) in Isfahan, Iran

Lahore Fort (1556 - 1605) in Pakistan, 10-point pattern
Girih Tiles
Girih Tiles - Background

- Islamic art features intricate geometric tilings used to decorate mosques and shrines
- Was originally thought these patterns were made using straightedge and compass
  - Some of them, especially later ones, too complex
- Topkapı Scroll discovered in 1986
  - Prepared in Iran in late 15th century
  - Revealed the use of Girih Tiles in the construction of these intricate designs and patterns

Shah Mosque in Isfahan, Iran
What are Girih Tiles?

- A set of five tile types used for creating tiling patterns for the decoration of buildings
  - A regular decagon (144°)
  - An elongated hexagon (72°, 144°, 144°, 72°, 144°, 144°)
  - A bowtie (72°, 72°, 216°, 72°, 72°, 216°)
  - A rhombus (72°, 108°, 72°, 108°)
  - A regular pentagon (108°)
- Edges of fives tiles are the same length
- Decorating lines (girih) incorporated into tiles
  - When tiles are combined, girih form an interlaced strapwork that comprises the designs on buildings
Girih Tiles cont’d.

- Every edge intersected at midpoint by two decorating lines at fixed angles
  - Ensures that lines continue across edges from one tile to another
- This strapwork is usually what appears on buildings (along with minor decorations like flowers)
  - Actual borders of tiles are not seen

Seljuk Mama Hatun Mausoleum in Tercan, Turkey
Spandrel from the Abbasid Al-Mustansiriyya Madrasa in Baghdad, Iraq
Interior ceiling on a vault in the gallery of the Ilkhanid Uljaytu Mausoleum in Sultaniya, Iran
Mamluk Quran of Aydughdi ibn Abdallah al-Badri
Two level designs

- Some girih patterns had much more complex pattern than originally seen
- Aperiodic - patterns do not repeat themselves
  - Lacks translational symmetry  
    (shifted copy never matches original exactly)
- Found two levels of Girih patterns
Two level Designs Cont’d

1. Large Scale Girih Pattern

2. Subdivision rule transforming large bowtie and decagon into small scale girih pattern

3. Reconstruction of small scale pattern
Conventional patterns that completely cover surface (such as floor tilings) are repetitive/periodic.

Some shapes (e.g., hexagons) can only be arranged periodically.

For several years, mathematicians believed there were no shapes that could be only arranged non-periodically.

Roger Penrose in 1974 identified only two shapes (“kites” and “darts”) that created exclusively non-periodic tiling.
Penrose Tiling cont’d

- As pattern made of two Penrose shapes expand, proportion of kites to darts approaches golden ratio ($\approx 1.618$)
- In 1984, physicist observed 3-D example of Penrose pattern in material world
- Alloy produced in laboratory showed same kind of non-periodic patterns previously only known theoretically from Penrose tiling
- Discovery described as “quasi-crystal”
  - Shared some defining properties of crystals, but lacked regular repeating structure
Relation to Girih Tiles

- In 2007, Peter Lu recognized similarity between girih and Penrose tiling.
- Found that five girih tiles could be further reduced to two shapes - Penrose “kites” and “darts”.
- Islamic architects had this advanced mathematical knowledge five centuries before its discovery by the West.

Pattern from Darb-i Imam Shrine represented as Penrose pattern
Muqarnas - 3D Architecture
Muqarnas - outline

1. What are they?
2. How were they constructed?
3. What geometric patterns are found within these structures?
1-What are they?
-Structure built in the interior of a half dome ceiling. It consists of many squinches making their way down the wall.

Fatima Musameh Shrine, Qom, Iran
Squinch: “Curved wall” linking a ceiling to a floor.

With muqarnas, a ceiling will be the floor of the layer above it.
2- Construction

1- Make schematics for the structure. (shown next slide)

2- Carve out layer floors+ceilings out of plaster

3- Assemble the layer bases on the dome or arch.

4- Link layers via squinches
Schematics example
Sheikh Luft Allah
Mosque
Isfahan, Iran
Geometry

Geometrical construction of a squinch:

- AB = 2BC = 2AK
- BCD = 30 degrees
- CX = (⅗)CD

Muqarna squinch

Stacked squinches
Patterns Within Squinches: “Faces”

**ETP:** Edge to point. Must come down from a sharp corner.

**PTE:** Point to edge. Must come down from ETP or ETE squinch.

**ETE:** Edge to edge (no point). Must come down From ETP or another ETE
Cairo, Egypt
Fatima Musameh Shrine, Qom, Iran
Nashir al Musk Mosque, Iran
Influence of Islamic Architecture on Contemporary Styles
Islamic Influence on American Architecture

- Earliest influence dates back to the 1700s in the form of Spanish Moorish buildings
- These influences are reflective of Moorish Revival Architecture which was adopted by architects in Europe and the Americas
  - Moorish Revival style remained popular up through the 19th and 20th centuries, but reached height of popularity during latter half of 19th century
- Associated with Romanticism and its fascination with exoticism and the Orient
  - Catered to American taste for the exotic
- As a result, had the unfortunate effect of reinforcing stereotypes rather than presenting an authentic depiction of Islamic design
- Nevertheless, it introduced foreign influences to American audience and paved the way for more sophisticated design
Examples of Moorish Revival Architecture

Fox Theatre (Atlanta, Georgia)
Lincoln Theater (Los Angeles, California)
Angeles Abbey Memorial Park Cemetery (Los Angeles, California)
Ripley’s “Believe It or Not” Museum (Grand Prairie, Texas)
Alcazar Theater (San Francisco, California)
Questions?
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