

Sound Techniques in Ancient Civilizations: An Analytical Study of the Geometric Shapes of Places of Worship

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Abstract Sound techniques in ancient civilizations have long fascinated researchers and archaeologists, as they provide a unique window into the beliefs, practices, and technological advancements of past cultures. One of the most intriguing aspects of sound techniques in ancient civilizations is the use of geometric shapes in places of worship. From the pyramids of Egypt to the temples of Greece, ancient cultures employed sophisticated acoustic techniques to create spaces that were not only aesthetically pleasing but also resonant and reverberant. In this essay, we will conduct an analytical study of the geometric shapes of places of worship in ancient civilizations, examining their acoustic properties and the possible reasons behind their design. We will focus on three ancient civilizations: Egypt, Greece, Mesopotamia, and the Sagrada Familia church and explore their use of sound techniques in their religious architecture.

Keywords: *religious architecture, ancient civilizations, sound techniques, islamic civilization, sagrada familia*

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1. Introduction

Sound systems play a crucial role in the realms of culture, architecture, and religion, enhancing and shaping human experience in profound ways. From ancient civilizations to modern societies, the use of sound has been intertwined with the expression of human creativity, the design of architectural spaces, and the practice of religious rituals [1].

In the cultural context, sound systems have been employed to convey narratives, preserve traditions, and evoke emotions. Whether through traditional music, storytelling, or theatrical performances, cultural soundscapes immerse individuals in a rich tapestry of sounds, melodies, and rhythms that reflect the essence of a particular community or heritage. Sound systems in cultural settings serve as powerful vehicles for transmitting collective memory, fostering a sense of belonging, and promoting cultural identity [2].

In architecture, sound systems are an integral part of the design process, shaping the acoustic qualities of spaces and influencing the way people perceive and interact with their environment. Architects and acoustic engineers carefully consider the reverberation, sound reflection, and diffusion within buildings to create optimal soundscapes for various purposes. Concert halls, theaters, and religious structures are meticulously designed to enhance the

auditory experience, ensuring that music, speeches, or religious ceremonies are delivered with clarity, resonance, and emotional impact [3].

Religious practices across different faith traditions have long embraced the use of sound systems as a means of spiritual expression and congregation. The sound of chants, prayers, hymns, and sacred music resonates within religious spaces, creating a profound atmosphere conducive to devotion, meditation, and communal worship. The design and placement of sound systems within religious edifices are carefully considered to amplify the voices and music, allowing the faithful to engage in collective spiritual experiences and connect with the divine [4].

2. The pyramids of Egypt

The pyramids of Egypt are perhaps the most iconic examples of ancient places of worship, and their geometric shapes have been the subject of much study and speculation. The Great Pyramid of Giza, built for the pharaoh Khufu, is the oldest and largest of the pyramids, and its unique geometry has been found to have significant acoustic properties [5].

The pyramid's shape, a triangular prism with smooth sides, was designed to be resonant, with the base and height in a 3:4 ratio. This ratio creates a harmonic relationship between the pyramid's dimensions, resulting in a unique acoustic signature. Studies have shown that

when sound waves are directed at the pyramid's base, they reverberate and form standing waves that resonate throughout the structure [6].

These standing waves were likely used in ancient Egyptian religious rituals, where priests would chant and play instruments to create a reverberant atmosphere. The pyramid's acoustics were also believed to have healing properties, with the resonance said to have the power to heal ailments and imbalances in the body [7].

The pyramid's internal chambers, including the King's Chamber and the Queen's Chamber, also show evidence of sophisticated acoustic design. These chambers have a unique relationship with each other, with their dimensions and shapes creating a system of resonance that amplifies and focusses sound waves [8].

3. Greek Temples

In ancient Greece, temples were built to honor the gods and goddesses of the Greek pantheon. These temples were designed with precise geometric shapes, with the aim of creating spaces that were both aesthetically pleasing and acoustically resonant [9].

The Parthenon, a temple dedicated to the goddess Athena, is one of the most famous examples of Greek temple architecture. Its design features a series of rectangular and triangular shapes, which create a unique acoustic signature. Studies have shown that the Parthenon's geometry creates a series of standing waves, which would have been used in religious rituals and ceremonies [10].

The Parthenon's acoustics are also notable for their ability to amplify sound waves. The temple's design features a series of convex surfaces, which reflect sound waves and create a sense of reverberation. This effect would have been particularly pronounced during the ancient Greek practice of "eche", where priests would chant in unison, creating a powerful, resonant sound [11].

4. Mesopotamian Ziggurats

In ancient Mesopotamia, the ziggurats were massive temples built to honor the gods and goddesses of the Mesopotamian pantheon. These structures were designed with stepped pyramidal shapes, which created a unique acoustic environment [12].

The Great Ziggurat of Ur, built for the moon god Nanna, is one of the most well-preserved examples of a Mesopotamian ziggurat. Its stepped pyramidal shape creates a series of terraces, each of which would have been used for religious rituals and ceremonies [13].

Studies have shown that the ziggurat's geometry creates a series of standing waves, which would have been used to amplify and focus sound waves during religious ceremonies. The terraces also feature a series of small rooms and chambers, which would have been used for private worship and meditation [14].

5. The Minaret

This minaret is distinguished by its round body,

thinness, and great height. It is an architectural unit separate from the original mosque. It has a circular plan, tapering in diameter as we go upward, and it consists of five layers. The first layer takes a polygonal shape in the form of a half cylinder, and a triangular shape alternately, over which extend friezes of Qur'anic writings engraved on the stone, while the second layer appears to be smaller in diameter than the first with semi-cylindrical ribs, and two inscription bands executed with relief engraving extend over the body of the minaret, while the diameter of the third layer is less than a second, with adjacent, prominent ribs [15]. The fourth layer appears to be cylindrical, non-ribbed, devoid of decoration. The fifth, smooth, cylindrical tier is separated from the fourth by a balcony based on vaults that are less ornate than the three lower balconies, and ends at the top with a balcony, in the middle of which is a small hull surmounted by the top of the minaret [16]. One of the most famous minarets is the Minaret of the Bride in the Umayyad Mosque in Damascus, which many consider to be the first minaret built in the Islamic era that has survived to us. In terms of clay construction, the towering minaret of the Sheikh Omar Al-Mihdhar Mosque in Tarim, Yemen, is the most famous and tallest clay minaret in the world, reaching a height of 175 feet. It is square in shape and has a staircase inside to climb to the top. It is distinguished by the fact that it is built of mud and palm trunks, despite its high height. Minarets of the era of towers [17].

6. Modern Era Building

In the modern era, the art of building minarets benefited from engineering and technical developments, and the minarets of mosques became the highest, and some of them exceeded a hundred meters in height. In this regard, the minarets of the Two Holy Mosques stand out, as the largest minaret in the world was built in the Meccan Mosque, which was crowned with the largest wall clock entered in the Guinness Book of Records [18]. Also, 10 minarets were raised in the Holy Mosque, making it the first mosque with the number of minarets, followed by the Meccan Mosque with nine minarets. The tallest minaret in the world was also built, with a height of 210 metres, in the Hassan II Mosque in Morocco, followed by the minaret of the Al-Fath Mosque in Cairo, which has a height of 130 metres, then the minarets of the second expansion in the Prophet's Mosque, with a height of 105 metres, followed by the minarets of the Grand Mosque in Mecca, which has a height of 92 metres. The Sheikh Zayed Bin Sultan Mosque in the Emirates is distinguished by four minarets covered in white marble, which tower over the corners of the outer court at a height of 107 metres, and are dispersed around the main dome, which is the largest dome in the world and reaches a height of 83 metres. In Yemen, there are six minarets on the sides of the Al-Saleh Mosque in Sana'a, in their Yemeni architectural style, with yagur, and engraved with lime plaster. Four of them are 100 meters high, and two are 80 meters high. The lower part of the first four minarets is built of white stone, and the upper part is built of yagur and white stone, and the lighthouse has three. Balconies. Each minaret is topped

by a crescent rising five metres. As you watch the lighthouses, you wonder how they perform their function of conveying sound, and the issue of the muezzin climbing the spiral staircase to the balconies. But with developments and discoveries, things changed [19]. The fear of the muezzin of ascending was removed, and the muezzin no longer had to have a loud, long-breathed voice. Instead of climbing long stairs, an electric wire was used to deliver the sound to the top of the lighthouse where the loudspeaker was, while the muezzin announced the call to prayer from the mihrab of the mosque as seen in Figure 1.



Figure 1. Mosque with minarets



Figure 2. History of minaret construction is far more intricate and diverse, shaped by continuous development and evolution across the East and West of the Islamic world

Minarets, soaring towards the heavens, grace the skylines of cities throughout the Islamic world. They stand as prominent visual symbols, instantly conveying the religious identity, Islamic civilization, and unique architectural style of their surroundings [20]. While a single image may evoke a collective consciousness, presenting these minarets as vertical structures rising above their surroundings, the history of minaret construction is far more intricate and diverse, shaped by continuous development and evolution across the East and West of the Islamic world as depicted in Figure 2.

From an architectural perspective, minarets are defined as vertical units that serve as visual markers for places of worship, namely mosques. They serve as the starting point for the call to prayer, notifying people of the designated times for prayer. Whether in bustling neighborhoods, quiet streets, or even in the desert, minarets proudly display banners, informing passers-by that they are in the vicinity of a place where the five daily prayers are performed [21].

Since the emergence of the Umayyad state in the Levant, Islamic architecture has evolved in response to geographical factors and the materials available for construction. Consequently, minarets have witnessed varying heights and endured the test of time. Notable examples include the minaret of the Kairouan Mosque, built by Bishr ibn Safwan (105-109 AH / 724-729 AD), and the minaret of Qasr al-Hayr al-Sharqi (110 AH/730 AD) in the Levant [22].

As Islamic countries expanded and smaller states emerged, distinct architectural styles emerged, adding further richness and diversity to Islamic civilization. Minarets became a competition ground for these smaller states, showcasing functionality, conveying information, and embodying religious symbolism. They served as guides for neighborhoods and streets, assisting visitors navigating through the cities. Furthermore, fires were often lit at the top of minarets to warn of approaching enemies. Historians have recounted how news would travel through minarets in a single night, spanning from Ceuta on the Strait of Gibraltar to Alexandria, despite the months-long journey between them [23].

During the Mamluk era, minarets took on a square base of modest height, adorned with an octagonal body in most cases, or occasionally a round shape. Rows of small muqarnas supported balconies for the muezzin. The upper section, known as the choir, varied in shape from octagonal to round, featuring solid or hollow walls. This era also witnessed the influence of Andalusian art on Egyptian architectural styles [24].

The Bahri Mamluks introduced the concept of incense burner-style minarets. For instance, the minaret of Zawiyat al-Hinud in Damascus (1250 AD) closely resembled the minaret of al-Salih Najm al-Din Ayyub, featuring a tall square body topped with an octagonal tier, an octagonal neck, and finally an incense burner. Similar examples include the minaret of Ahmad Ibn Tulun, erected by Sultan Lajin, and the lighthouse of the Great Mosque of Rome, which consisted of two layers resembling stacked incense burners. Notably, the Al-Aqsa Mosque in Rabwah, Badshahi Mosque in Lahore, Pakistan, Idgah Mosque in Kashgar, China, and Jami Mosque in Delhi, India, showcase these incense burner-style minarets, with varying sizes and exquisite architectural features

such as red yaguri motifs, topped with white domes and shiny copper crescents [25].

In the early Ottoman era, the pencil model emerged, replacing the square minaret. It soared high alongside massive domes or among a cluster of domes resembling pointed helmets, adorned with copper crescents. These formations resulted in a grand architectural ensemble, featuring numerous projections and bulges [26].

The mosques in Istanbul, particularly the Sulaymaniyah Mosque, became renowned for this pencil model. The minarets of the Sulaymaniyah Mosque stood tall and remarkably slender, with a cylindrical body composed of concave channels or convex ribs in a vertical arrangement. Horizontal bands served as balconies for the muezzins, and the minaret culminated in a cone with an acute-angled apex. The pencil model experienced significant development, evident in the illustrations of minarets. The top section gradually assumed a conical shape, resembling a slender spear. The balconies encircling the minaret appeared like decorative bracelets, dividing the layers, leading up to the thin conical shape. This evolution was particularly notable in the six minarets of the Sultan Ahmed Mosque in Istanbul (Blue Mosque), constructed during the reign of Ottoman Sultan Ahmed I [27].

In the 1960s, innovative designs and new models emerged, reminiscent of rockets ready for launch. The minarets of the King Faisal Mosque in Islamabad, Pakistan, exemplify this trend. Shaped like hexagonal Arab tents, the mosque features four minarets at its corners. These minarets were designed in a rocket-like manner, with hexagonal bases gradually tapering towards the top and ending in sharp points. This modernist approach to minaret design reflects the architectural trends of the time and showcases the creativity and innovation of contemporary Islamic architecture [28].

In recent years, there has been a resurgence of interest in traditional architectural styles, including minarets. Many new mosques are being built with minarets that draw inspiration from historical designs and incorporate traditional elements. These minarets often feature intricate geometric patterns, calligraphy, and ornamental details that pay homage to the rich architectural heritage of Islamic civilization [29].

It's important to note that minaret designs can vary greatly depending on the region, cultural influences, and architectural preferences. The examples mentioned above are just a few illustrations of the diverse styles and forms that minarets have taken throughout history. Each minaret carries its own unique story and contributes to the visual tapestry of the Islamic world [30].

Thus, minarets hold significant cultural, architectural, and religious importance in the Islamic world. They have evolved over time, reflecting the historical, social, and artistic influences of the regions in which they are found. Whether they are towering structures or modest in size, minarets continue to serve as iconic symbols of Islamic architecture, faith, and identity.

7. The Sagrada Familia Church

The Sagrada Familia Church, located in the Eixample district of Barcelona, Catalonia, Spain, is an

unfinished Roman Catholic cathedral that holds great architectural and historical significance. Designed by the renowned Spanish/Catalan architect Antoni Gaudí (1852-1926), the church is an integral part of a UNESCO World Heritage Site [31].

Construction of the Sagrada Familia began on March 19, 1882, under the supervision of architect Francisco de Paula del Villar. However, Gaudí took over as the chief architect in 1883 when Villar resigned, and he transformed the project with his distinctive architectural and geometric style. Gaudí's vision blended the elements of Gothic art with the flowing curves of Art Nouveau, resulting in a unique and enchanting design [32].

Gaudí dedicated the rest of his life to the Sagrada Familia, considering it his magnum opus. He was buried in a crypt within the church. However, at the time of his death in 1926, only a small fraction of the project had been completed. The construction progress was slow due to relying solely on private donations, and it was further interrupted by the Spanish Civil War. During the war, partisans set fire to the cellar and vandalized Gaudí's original plans and models, leading to a 16-year effort to reconstruct the master model [33].

Construction resumed sporadically in the 1950s, and advancements in technology, such as computer-aided design and computer numerical control, facilitated faster progress. By 2010, construction had surpassed the halfway point. The completion target for the entire project is set for 2026, which marks the centenary of Gaudí's death [34].

The Sagrada Familia features several towers, each symbolizing an important figure from the New Testament of the Bible. Gaudí's original design called for a total of eighteen towers, representing the twelve Apostles, the Virgin Mary, the four Evangelists, and the tallest tower symbolizing Jesus Christ. As of 2010, eight towers had been completed, corresponding to the apostles depicted on the Nativity and Passion facades as seen in Figure 3.



Figure 3. Sagrada Familia nave roof

Gaudí's unique architectural style drew inspiration primarily from nature, setting him apart from other artists and architects of his time. While he incorporated elements of Cubism and Art Nouveau in the intricate decorations of the Nativity facade towers, his designs resisted easy categorization [35].

The architectural elements of the Sagrada Familia also include hyperbolic structures. Although not prominent in the controlled surface design of the facade, there are instances where hyperbolic forms appear, such as in the scenes with swans and the Bishop Miter towers [36].

The completion of the towers and spires will follow Gaudí's original intentions. The central tower dedicated to Jesus Christ will be crowned with a giant cross, while the towers of the Evangelists will feature sculptures representing their traditional symbols. The height of the spire of the Virgin Mary will be shorter than initially envisioned, aligning with recently discovered drawings signed by Gaudí. The lower towers will showcase figures of wheat sheaves and chalices with grape bunches, symbolizing the Eucharist [37].

Gaudí also paid attention to the acoustics of the Sagrada Familia, conducting studies to ensure optimal sound quality inside the temple. Plans include placing tubular bells in the towers, which will be activated by the force of the wind, creating a unique soundscape within the church. Currently, only one bell has been installed.

Throughout its history, the Sagrada Familia has been a subject of debate and controversy among Barcelona residents. Discussions have arisen regarding its potential rivalry with the Barcelona Cathedral, Gaudí's design choices, the adherence to his plans after his death, and proposals for construction projects near the church that could affect its stability [38].

Art critics and architectural experts have marveled at the Sagrada Familia, considering it an unparalleled masterpiece in the history of art. The church's intricate details, visionary design, and Gaudí's personal interpretation of Gothic architecture have garnered praise and admiration from around the world [39].

It's important to note that the Sagrada Familia is not the cathedral church of the Archdiocese of Barcelona, as that title belongs to the Cathedral of the Holy Cross and Saint Eulalia. Nonetheless, the Sagrada Familia stands as an iconic symbol of Barcelona and a testament to Gaudí's genius and dedication [40].

8. Conclusion

sound systems hold immense significance in cultural, architectural, and religious contexts. They facilitate the transmission of cultural heritage, shape architectural spaces to optimize acoustic experiences, and contribute to spiritual engagement and communal worship within religious communities. The thoughtful integration of sound systems in these realms enriches our lives, fosters a deeper understanding of our cultural heritage, and creates transformative spaces for human expression and connection.

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