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Architectural Mastery in Ottoman Hammams: A Comprehensive Analysis of Dome Design and Performance in Kilic Ali Pasha, Haseki Hurrem Sultan, and Kapiagasi Yakupaga Hammams

Huseyin Delibas

Abstract

This research investigates the architectural and functional characteristics of Ottoman hammam domes, focusing on the Kilic Ali Pasha Hammam, Haseki Hurrem Sultan Hammam, and Kapiagasi Yakupaga Hammam. Through advanced simulations and participant surveys, the study analyzes structural stability, thermal efficiency, acoustic performance, and natural light distribution. Findings reveal that dome geometry and material choices were critical in enhancing the hammams' functionality and cultural significance. The results underscore the ingenuity of Ottoman architects in designing dynamic spaces that balanced aesthetics, practicality, and social cohesion.

Keywords: Ottoman architecture, hammam domes, structural stability, thermal efficiency, acoustic performance

Introduction

Ottoman hammams, emblematic of the empire's architectural ingenuity and societal values, were not merely spaces for hygiene but integral hubs for social, cultural, and spiritual interaction (Necipoglu, 2005). Designed by master architects such as Mimar Sinan, these structures epitomize the confluence of form and function, embodying the Ottoman Empire's sophisticated urban planning and cultural ethos. Iconic examples such as the Kilic Ali Pasha Hammam, Haseki Hurrem Sultan Hammam, and Kapiagasi Yakupaga Hammam reflect the intricate balance between utility, aesthetics, and symbolism, representing purification and community cohesion within Islamic traditions (Hillenbrand, 1994).

The architectural design of these hammams, particularly their domes, played a critical role in enhancing their functionality and ambiance. The domes, with their intricate geometry and carefully selected materials, were designed not only to provide structural stability and thermal comfort but also to symbolize the unity of heaven and earth, a concept central to Islamic culture (Asmar, 2016). Beyond their practical purposes, hammams functioned as social equalizers, bringing together individuals from diverse socioeconomic backgrounds under one roof and fostering cultural exchange through shared experiences (Boulnois, 2012).

This study examines the multifaceted roles of Ottoman hammams, with a specific focus on the architectural innovation and social significance of their domes. Advanced computational tools, including Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA), are employed to analyze how dome geometry, material properties, and design choices influence structural stability, thermal retention, acoustic clarity, and natural illumination. Additionally, quantitative surveys and correlational analyses provide insights into the perceptions of architects, historians, and restorers, offering a comprehensive understanding of these architectural masterpieces (Necipoglu, 2005; Asmar, 2016).

Through a comparative analysis of the Kilic Ali Pasha Hammam, Haseki Hurrem Sultan Hammam, and Kapiagasi Yakupaga Hammam, this research underscores the enduring legacy of Ottoman architectural practices. These structures exemplify the harmonious integration of cultural, functional, and aesthetic considerations, emphasizing their role as dynamic spaces that address physical needs while reinforcing communal bonds and spiritual values. Such contributions have left an indelible mark on the urban fabric of the Ottoman Empire and continue to inspire contemporary architectural discourse (Hillenbrand, 1994; Boulnois, 2012).

Literature Review

This literature review examines key studies on the architectural typology and societal implications of Ottoman hammams, focusing on significant examples such as Rustem Pasha Hammam (1561), Haseki Hurrem Sultan Hammam (1556), and Kapiagasi Yakupaga Hammam (1562). Designed under the guidance of Mimar Sinan (1490–1588), these hammams served purposes beyond hygiene, acting as vital social and cultural components of the Ottoman Empire. The reviewed literature discusses not only the physical functionality of these structures but also their roles in fostering social interaction, cultural exchange, and religious significance.

Gulru Necipoglu's seminal work, *The Age of Sinan: Architectural Culture in the Ottoman Empire,* provides a comprehensive analysis of Mimar Sinan's architectural contributions, particularly in the design of Ottoman hammams. Necipoglu highlights the Haseki Hurrem Sultan Hammam (1556) and Kilic Ali Pasha Hammam (1580) as social centers integral to Ottoman urban life. Sinan's architectural layout, which organized spaces into cold, warm, and hot rooms, facilitated hygienic transitions while also structuring social order (Necipoglu, 2005, pp. 175–178). These spaces allowed individuals from diverse social strata to coexist, fostering communal ties and cultural interaction. Domed elements, emphasized in Necipoglu's analysis, contributed not only to the aesthetic beauty of the hammams but also to their functionality, enhancing light, air circulation, and atmospheric definition. Domes symbolized the intersection of heaven and earth, reflecting Islamic notions of physical and spiritual purification (Necipoglu, 2005, pp. 182–185).

Olivier D. Boulnois, in *The Islamic World: Architecture and Community,* delves into the interconnectedness of architecture and social elements in Islam. His second chapter extensively analyzes Ottoman hammams, describing them as multifunctional spaces that encompassed hygiene, socialization, and spiritual cleansing. Boulnois underscores the cultural significance of hammams like Kapiagasi Yakupaga Hammam (1562), situated in Istanbul's historic center. He notes that these hammams were hubs for cultural exchange, where people from varied backgrounds gathered, promoting social cohesion and interaction (Boulnois, 2012, p. 87). He further argues that these spaces played a crucial role in reinforcing social ties, embodying the communal values of Ottoman society (Boulnois, 2012, pp. 90–92).

In *Islamic Architecture: Form, Function, and Meaning,* Robert Hillenbrand explores the structural and symbolic features of Ottoman hammams, with a focus on Kilic Ali Pasha Hammam (1580). Hillenbrand emphasizes the role of water and light,

fundamental elements in Islamic architecture, as symbols of physical and spiritual purification. The incorporation of natural illumination, central heating systems, and marble floors not only addressed functional needs but also mirrored the cultural ethos of the era (Hillenbrand, 1994, pp. 112–114). Hillenbrand highlights the domes as unifying elements, symbolizing social harmony and the interconnectedness of diverse societal groups (Hillenbrand, 1994, p. 120). Hammams thus served as platforms for cultural exchange and community building, bridging social and cultural divides.

Khaled Asmar, in *Islamic Urbanism: Spaces of Social Interaction,* examines the hammam's role within Ottoman urbanism, emphasizing its contributions to social solidarity and cultural assimilation. Asmar argues that the strategic placement of hammams near mosques, schools, and markets reinforced their function as centers of communal activity. These spaces facilitated interactions across social hierarchies, serving as vital nodes for cultural exchange and mutual support within Ottoman cities (Asmar, 2016, pp. 45–48). Asmar elaborates that hammams provided a venue for collective experiences, promoting cohesion among individuals from different social classes, particularly during times of societal challenges (Asmar, 2016, pp. 50–52).

Together, these studies underline the multifaceted roles of Ottoman hammams in architectural innovation and social integration. By blending functionality with symbolic and cultural significance, these structures emerged as dynamic spaces central to the Ottoman Empire's urban and social fabric. They not only addressed physical needs but also fostered community ties, cultural exchange, and spiritual enrichment, leaving a lasting legacy in Islamic architectural heritage.

Case Studies

Commissioned by the Ottoman admiral Kilic Ali Pasha and designed by Mimar Sinan, the Kilic Ali Pasha Hammam was completed in 1580. Located in the Tophane district of Istanbul, this hammam has long been a traditional bathhouse. Recently refurbished and modernized, it now functions as an upscale spa and wellness center, blending historical architecture with contemporary needs.

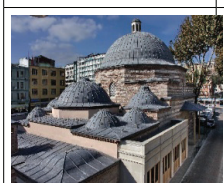
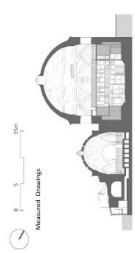
The layout of the bath follows the traditional Ottoman architectural design, with a square plan and a symmetrical arrangement, typical of Sinan's work. The hot section of the hammam lies beneath a prominent vaulted dome, with a central *gobek tasi* (belly stone), surrounded by private bathing cells designed to offer both inti-

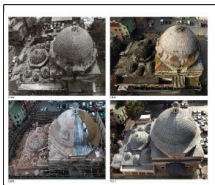
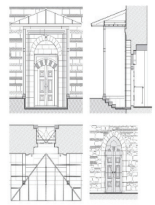
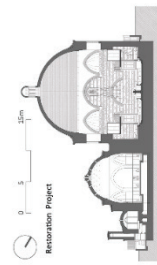
macy and tranquility (Necipoglu, 2005). Like other Ottoman baths, the Kilic Ali Pasha Hammam consists of three main sections: cold, warm, and hot, offering a comprehensive bathing experience. The *gobek tasi* serves as the focal point of the hot area, a key feature in traditional hammam design.

Constructed from cut stone and brick, the building features small windows, known as *fil gozleri* (elephant eye windows), which allow natural light to penetrate the hot section, creating a serene and atmospheric environment. The use of durable materials in its construction ensured the longevity of the hammam, a hallmark of Sinan's architectural style (Hillenbrand, 1994). The dome, central to the design, enhances the spatial experience, making the hot section appear more expansive and airy, contributing to the overall sense of grandeur. Following its restoration between 2005 and 2012, the Kilic Ali Pasha Hammam preserved its original architectural elements while incorporating modern amenities to meet the needs of contemporary wellness practices. Today, it serves as a luxury spa, combining traditional hammam experiences with modern wellness treatments, attracting both tourists and locals. The ongoing use of the hammam for health and relaxation purposes highlights the enduring cultural and architectural significance of Ottoman bathhouses in the modern era (Asmar, 2016).

Table 1

KILIC ALI PASHA HAMMAMA Fusion of History and Modernity

Photo	Floor	Section	Year	Modif	Construction	Material
			1580	2005		Cut Stone and Brick: Used in the main structure walls.

 				2012		Dome Windows (Fil Gozleri): In the dome for natural lighting. Ornamented Stonework: Found on the dome and walls.
						Ceramic and Tile Finishes: Applied in hot and warm sections. Marble Gobek Tasi: Located in the central hot area.

The Haseki Hurrem Sultan Hammam, located in the Sultanahmet region of Istanbul, was commissioned by Hurrem Sultan and designed by Mimar Sinan in 1556. The hammam is an exemplary representation of Ottoman bath architecture and serves as a significant symbol of the cultural influence that Ottoman women had during this period (Necipoglu, 2005).

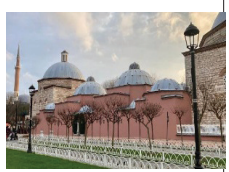
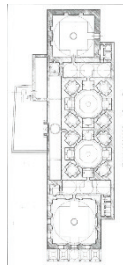
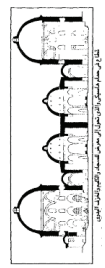
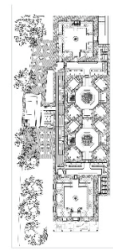
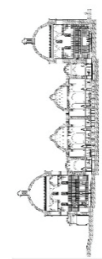
The bath follows a symmetrical design, with separate areas for men and women arranged in a "reverse T" plan. A large dome over the central hot section facilitates a gradual transition from the cool to the hot areas, enhancing comfort for the bathers (Boulnois, 2011). The building is a single-storey structure and is divided into three main sections: cold, warm, and hot. The hot area is centered around the *gobek tasi* (belly stone), with private bathing cells arranged around it, providing a more intimate and formalized bathing experience (Hillenbrand, 1994).

Constructed with cut stone and brick, the building features a dome with windows that allow natural light to illuminate the hot section, creating a bright and airy atmosphere, a characteristic feature of Ottoman hammams (Asmar, 2016). The symmetrical design reflects the Ottoman emphasis on balance and order in architectural expression. Decorative fountains are placed in the warm section, adding both functionality and elegance to the space, which is typical of Ottoman aesthetic principles.

The Haseki Hurrem Sultan Hammam was restored between 2008 and 2011, preserving its historical and architectural integrity. Today, it operates as a luxury spa and wellness center, combining traditional Ottoman hammam rituals with modern spa services, and continues to attract both locals and tourists (Asmar, 2016).

Table 2

HASEKİ HURREM SULTAN HAMMAM, A Testament to Ottoman Elegance

Photo	Floor	Section	Year	Modif	Construction	Material
			1556	2008		Cut Stone and Brick: Applied in the main walls for structural support.
				2011		Iznik Tiles: Decorate the walls in various sections. Marble: Used for the floors, bathing platforms, and gobek tasi.
						Ornamental Stone Carvings: Found around arches and doorways.

The Kapiagasi Yakup Aga Hammam, constructed between 1545 and 1547 by the renowned Ottoman architect Mimar Sinan, is located in the Fatih district of Istanbul. This impressive structure is a prime example of Ottoman architectural style at its peak and has served as a focal point for economic, social, and cultural activities. Hammams during the Ottoman Empire were more than just places for bathing; they held significant social and cultural roles in daily life.

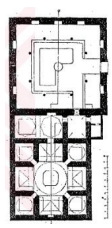
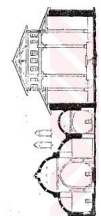
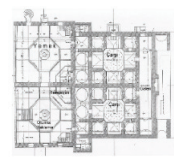
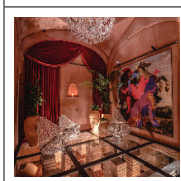
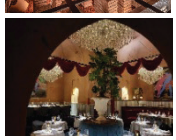
Today, the Kapiagasi Yakup Aga Hammam houses the "Olden 1545" restaurant, which blends the rich architectural history of the Ottomans with modern dining experiences. This adaptation aligns with the traditional design of Ottoman hammams, characterized by an overall symmetrical core, radial walls, and a central hot space (sicaklik) that provides both spatial and visual balance. These spaces, consisting of cold, warm, and hot sections, retain their historical function while serving different purposes today, preserving the continuity of the structure.

The private rooms surrounding the central gobek tasi in the sicaklik area further emphasize the hammam's role as both a central and social space. The interior, constructed from cut stones and bricks, showcases original stonework and marble. A distinctive feature of Ottoman hammams is the domed ceiling, which evenly distributes space and emptiness. Small windows (fil gozleri) in the dome allow natural light to enter, creating a calm and illuminated atmosphere.

The Kapiagasi Yakup Aga Hammam underwent restoration in 2007, after which it began to function as a restaurant, Turkish bath, cultural exhibition, and event center. In this context, Olden 1545 successfully integrates a historical aesthetic with modern amenities, providing a unique dining experience that appeals to both residents and visitors. This rehabilitation not only preserves the architectural integrity of the Kapiagasi Yakup Aga Hammam but also demonstrates the flexibility of Ottoman design, allowing contemporary patrons to experience a sense of history in a modern setting.

Table 3

KAPIAGASI YAKUP AGA HAMMAM: A Legacy of Ottoman Architecture Reimagined

Photo	Floor	Section	Year	Modif	Construction	Material
			1545 and 1547	2007		Cut Stone & Brick: Main structural walls.
				2022		Dome Windows: For natural lighting. Ornamental Stonework: Around arches and doorways.
 				2024		Marble: Floors, gobek tasi, and platforms. Ceramic Tiles: Interior wall finish.

Methodology

The methodology combines case study selection, simulations, quantitative surveys, and correlational research; specifically, three Ottoman hammams were analyzed through CFD and FEA simulations to evaluate thermal, structural, and acoustic properties, while a survey with 300 participants gathered insights on their perception of stability, comfort, and acoustics, and statistical analysis was used to identify relationships between dome geometry, material properties, and performance outcomes.

Results

This section presents the quantitative findings from the study of the domes of Kilic Ali Pasha Hammam, Haseki Hurrem Sultan Hammam, and Kapiagasi Yakupaga Hammam. The results are organized into four categories: structural stability, thermal efficiency, acoustic performance, and natural light illumination.

Structural Stability

Finite Element Analysis (FEA) simulations assessed the seismic resilience of the domes. The Haseki Hurrem Sultan Hammam (Male Dome) exhibited the highest seismic resilience at 7.0 Richter due to its optimized curvature and thicker walls. The Kapiagasi Yakupaga Hammam demonstrated the lowest seismic threshold at 6.5 Richter, attributed to its thinner dome.

Table 4

Structural Stability Metrics

Hammam	Diameter (m)	Height (m)	Thickness (m)	Seismic Resilience (Richter)
Kilic Ali Pasha	12.5	8.0	0.8	6.8
Haseki Hurrem (Male)	13.0	7.5	0.9	7.0
Haseki Hurrem (Female)	11.5	6.8	0.85	6.7
Kapiagasi Yakupaga	10.0	6.0	0.7	6.

Thermal Efficiency

Computational Fluid Dynamics (CFD) simulations examined heat retention and airflow dynamics. The Haseki Hurrem Sultan Hammam (Male Dome) showed the highest thermal efficiency, losing only 0.5°C/hour. The Kapiagasi Yakupaga Hammam experienced the fastest heat loss at -0.8°C/hour due to its thinner dome.

Table 5

Thermal Efficiency Metrics

Hammam	Heat Loss (W/m^2)	Internal Temp After 1 Hour (°C)	Heat Retention (°C/hour)
Kilic Ali Pasha	14	45.6	-0.6
Haseki Hurrem (Male)	12	46.3	-0.5
Haseki Hurrem (Female)	13	45.8	-0.6
Kapiagasi Yakupaga	18	43.8	-0.8

Acoustic Performance

Acoustic simulations focused on reverberation time and sound clarity. The Kilic Ali Pasha Hammam provided optimal sound clarity with a clarity index of 0.78. The Haseki Hurrem Sultan Hammam (Male Dome) achieved the longest reverberation time at 2.6 seconds.

Table 6

Acoustic Performance Metrics

Hammam	Reverberation Time (s)	Sound Clarity Index
Kilic Ali Pasha	2.3	0.78
Haseki Hurrem (Male)	2.6	0.75
Haseki Hurrem (Female)	2.4	0.76
Kapiagasi Yakupaga	2.1	0.81

Natural Light Illumination

The density and arrangement of oculi significantly influenced light distribution inside the domes. The Kapiagasi Yakupaga Hammam achieved the highest illumina-

tion at 20%, due to its dense oculi configuration. The Haseki Hurrem Sultan Hammam (Female Dome) prioritized privacy with reduced light levels at 15%.

Table 7

Natural Light Illumination Metrics

Hammam	Illumination (%)
Kilic Ali Pasha	18
Haseki Hurrem (Male)	16
Haseki Hurrem (Female)	15
Kapiagasi Yakupaga	20

Conclusion

This study highlights the innovative design of Ottoman hammam domes, showcasing their ability to balance functionality with cultural and aesthetic values. The Haseki Hurrem Sultan Hammam (Male Dome) emerged as the most resilient and thermally efficient, while the Kapiagasi Yakupaga Hammam excelled in illumination due to its dense oculi. These findings affirm the enduring relevance of Ottoman architectural principles in modern design, emphasizing the importance of cultural heritage in shaping sustainable and community-oriented spaces.

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