Research Article

Metric-Based Comparative Analysis of Seljuk and Byzantine Architectural Practices in Medieval Anatolia

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Abstract

The architectural landscape of medieval Anatolia represents a complex synthesis of Byzantine and Seljuk traditions, characterized by significant advancements in construction techniques and decorative methodologies. This study investigates the interplay between these two architectural traditions, analysing key elements such as stonework, tilework, and ornamental patterns. The Seljuks are renowned for their emphasis on intricate geometric motifs, calligraphy, and the innovative application of muqarnas, while Byzantine architecture is distinguished by its monumental scale, intricate masonry, and the extensive use of religious iconography, particularly mosaics. Despite their differing cultural and artistic ideologies, both traditions contributed profoundly to the evolution of Anatolian architecture.

Through the comparative analysis of emblematic structures, including the Great Mosque of Divriği, the Green Mosque in Bursa, and the Hagia Sophia in Constantinople, this research highlights mechanisms through which cultural exchange. Seljuk architects adopted and adapted Byzantine structural innovations, integrating them into Islamic artistic frameworks to develop a hybrid architectural style. Conversely, Byzantine structures, particularly in the post-Byzantine period, reflect Seljuk influences in their decorative schemes, including geometric patterns and muqarnas.

Employing a methodical comparative framework, the study evaluates the aesthetic and structural principles underpinning these traditions, revealing the sociopolitical and cultural dynamics that shaped their innovations. This synthesis of Byzantine structural ingenuity and Seljuk ornamental creativity produced a distinctive architectural identity in Anatolia that profoundly influenced the subsequent development of Ottoman architecture and Islamic design throughout the Middle East and Mediterranean. These findings underscore the region's role as a crossroads of artistic and technological exchange.

Keywords: Byzantine Traditions, Comparative Architectural Analysis, Seljuk Architecture, Cultural Exchange in Anatolia, Geometric Patterns.

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Araştırma Makalesi

Anadolu Selçuklu ve Bizans Mimari Uygulamalarının Metrik Tabanlı Karşılaştırmalı Analizi

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Özet

Ortaçağ Anadolu'sunun mimari manzarası, Bizans ve Selçuklu geleneklerinin karmaşık bir sentezini temsil eder ve yapı teknikleri ile süsleme yöntemlerindeki önemli ilerlemelerle karakterize edilir. Bu çalışma, taş işçiliği, çini kaplamalar ve süsleme desenleri gibi temel unsurları analiz ederek bu iki mimari geleneğin etkileşimini incelemektedir. Selçuklular, karmaşık geometrik motifler, hat sanatı ve mukarnas uygulamalarıyla tanınırken, Bizans mimarisi anıtsal ölçek, karmaşık taş işçiliği ve özellikle mozaiklerde kullanılan dini ikonografi ile öne çıkmıştır. Kültürel ve sanatsal ideolojilerindeki farklılıklara rağmen, her iki gelenek de Anadolu mimarisinin evrimine derin katkılarda bulunmuştur.

Divriği Ulu Camii, Bursa'daki Yeşil Cami ve İstanbul'daki Ayasofya gibi önemli yapılar üzerinden yapılan karşılaştırmalı analiz, kültürel etkileşim mekanizmalarını ortaya koymaktadır. Selçuklu mimarları, Bizans yapı tekniklerini benimseyerek İslami sanatsal çerçevelerle harmanlamış ve hibrit bir mimari üslup geliştirmiştir. Öte yandan, özellikle Bizans sonrası dönemde, Bizans yapılarında Selçuklu etkileri, geometrik desenler ve mukarnas gibi süsleme şemalarında görülmektedir.

Yöntemsel bir karşılaştırma çerçevesi kullanan bu çalışma, bu geleneklerin estetik ve yapısal ilkelerini değerlendirerek yeniliklerini şekillendiren sosyopolitik ve kültürel dinamikleri açığa çıkarmaktadır. Bizans'ın yapısal ustalığı ile Selçuklu'nun süsleme yaratıcılığının birleşimi, Anadolu'da özgün bir mimari kimlik oluşturmuş ve bu kimlik, Osmanlı mimarisinin ve Ortadoğu ile Akdeniz'deki İslam tasarımının sonraki gelişimlerini derinden etkilemiştir. Bulgular, bölgenin sanatsal ve teknolojik değişimlerin bir kesişim noktası olarak önemini vurgulamaktadır.

Anahtar Kelimeler: Bizans Gelenekleri, Karşılaştırmalı Mimari Analiz, Selçuklu Mimarisi, Anadolu'da Kültürel Etkileşim, Geometrik Desenler,

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INTRODUCTION

The Seljuk architectural tradition is one of the most impressive expressions of the cultural and artistic vitality of medieval Anatolia, serving as a bridge between the Byzantine and Islamic worlds (Redford, 1991). Byzantine architecture, renowned for its monumental churches and fortifications, served as a source of both artistic and technological innovation, influencing the architectural development of Anatolia for centuries (Hillenbrand, 1994). The interaction between artistic creativity and technological prowess in Seljuk and Byzantine architecture highlights how these two traditions navigated their cultural contexts while adapting innovative building techniques (Necipoğlu, 1995). The architecture of the Seljuks, influenced by Byzantine structural techniques, developed its own identity through innovative vaulting systems and ornamental schemes, embodying the cultural synthesis of medieval Anatolia (Blessing, 2014). Through a comparative analysis of these two architectural traditions, the study uncovers the unique features of each style and investigates how the interaction of art and technology shaped architectural identity and cultural expression in the region.

The architectural relationship between the Seljuk and Byzantine empires in Anatolia was shaped by both conflict and collaboration. This cross-cultural exchange saw the adoption and adaptation of architectural elements from each tradition. While the Seljuks integrated Byzantine innovations such as dome construction techniques and vaulting systems into their own brick structures, Byzantine architecture occasionally reflected Seljuk influences, particularly in ornamentation. However, each architectural style retained its unique identity, avoiding homogenization despite this exchange of ideas.

Anatolia served as a crossroads where Byzantine and Seljuk architectural traditions met and influenced one another. Despite adopting certain techniques from each other, both empires maintained their distinct cultural and religious identities, which were reflected in their architectural approaches. The Seljuks emphasized geometric patterns, calligraphy, and muqarnas, while the Byzantines focused on monumental stone construction and mosaic decoration. This dynamic exchange contributed to the architectural diversity of medieval Anatolia, creating a blend of styles that mirrored the region's rich cultural history. As scholars have noted, the interaction between the Byzantine and Islamic worlds was complex, resulting in mutual influence without compromising the core characteristics of either tradition.

LITERATURE REVIEW

The literature surrounding Seljuk and Byzantine architecture in Anatolia is extensive, offering diverse perspectives on the artistic, technological, and cultural exchanges between these two empires. Notable scholars such as Hillenbrand (2010, 2004), Ettinghausen et al. (2003), and Blair and Bloom (1994) provide comprehensive analyses of Islamic and Byzantine art and architecture, emphasizing the distinct characteristics of each tradition within its historical contexts.

Hill and Al-Hassan (1992) focus on the technological aspects of Seljuk architecture, particularly the construction techniques and materials that influenced ornamentation. Ettinghausen et al. (2003) explore the artistic achievements of the Seljuk period, highlighting architectural styles and ornamentation. Hillenbrand (2004) specifically examines the Seljuk period in Anatolia, noting the blend of Seljuk and Byzantine influences that shaped the region's unique architectural identity.

Approach	Study	Author(s), Publication Year	Specific Focus	Focus & Key Information	Relevance to Research
Holistic	Islamic Art and Architecture	Robert Hillenbrand, 2010	Comprehensive overview of Islamic art and architecture, including Seljuk styles.	Highlights the importance of geometric patterns, calligraphy, and floral motifs in Seljuk art.	Provides foundational knowledge on Seljuk ornamentation within Islamic art history.
Holistic	The Art and Architecture of Islam, 1250-1800	Sheila S. Blair and Jonathan M. Bloom, 1994	Evolution of Islamic art and architecture from the 13th century onwards, including Seljuk influences.	Discusses regional styles and the adaptation of ornamentation in different contexts.	Provides insights into the later development of Seljuk-influenced architecture.
Atomistic	Architecture of the Islamic World: Its History and Social Meaning	Ernst J. Grube and George Michell, 1995	Development of different architectural styles within the Islamic world, including Seljuk architecture.	Discusses the role of ornamentation and its cultural significance.	Offers a broad historical context for understanding Seljuk ornamentation.
Atomistic	Islamic Technology: An Illustrated History	Donald R. Hill and Ahmad Y. Al-Hassan, 1992	Technological advancements in Islamic architecture, covering construction techniques and materials used in Seljuk buildings.	Examines how these influenced the development of ornamentation.	Offers insights into the technological aspects of Seljuk architecture and how they impacted ornamentation.
Atomistic	Byzantine Architecture	Cyril Mango, 1985	Detailed analysis of Byzantine architecture, highlighting its unique structural and decorative features.	Explores its evolution across different periods.	Offers a foundational understanding of Byzantine architecture and its artistic innovations.
Atomistic	"The Art of the Byzantine Empire"	Grabar, A. 1967	Artistic achievements of the Byzantine Empire, examining its art and architecture within the broader context of the Eastern Orthodox Church.	Provides insights into the artistic and symbolic significance of Byzantine art, particularly in the context of religious expression.	Provides insights into the artistic and symbolic significance of Byzantine art, particularly in the context of religious expression.
Holistic	Islamic Art & Architecture: 650-1250	Richard Ettinghausen, Oleg Grabar, Marilyn Jenkins Madina, 2003	Comprehensive overview of Islamic art and architecture, including Seljuk architecture.	Explores its artistic principles, architectural features, and cultural significance.	Provides a broader context for understanding Seljuk art and architecture within the wider Islamic world.
Atomistic	A Survey of Persian Art (Vol. 8)	Arthur Upham Pope, Phyllis Ackerman, 1981	Persian art across historical periods, including Seljuk art and architecture.	Provides insights into the stylistic characteristics and influences on Seljuk art.	Offers a valuable resource for understanding the broader context of Seljuk art and its origins in Persia.

Table 1. Analyzed relative Studies on Seljuk and Byzantine Architecture in Anatolia, Source: Authors.

In the context of Byzantine architecture, foundational works by Mango (1985) and Grabar (1967) provide crucial insights into its structural and decorative innovations. Nazer, Kovács, and Rabb (2020) delve into the significance of Tomb Towers in Seljuk architecture in Persia and Anatolia, while Nazer (2016) examines the role of light in Islamic Mosque domes, both offering key insights into Seljuk architectural traditions

METHODOLOGY

The methodology for this comparative architectural study involved a multi-step process to systematically evaluate and compare the key architectural features of Seljuk and Byzantine structures. The steps are as follows:

• Case Study Selection: Buildings from the Seljuk and Byzantine traditions were carefully chosen for their iconic representation of architectural styles, focusing on key examples such as mosques, churches, and palaces within the Anatolian context.

• Define Key Metrics: For each architectural feature, key metrics were identified to evaluate both structural technologies (e.g., dome construction, vaulting systems) and decorative elements (e.g., mosaics, calligraphy). These metrics allowed for a structured comparison between the two traditions.

• Establish a Coding System and Quantitative Scoring: A coding system was established for each metric, assigning numerical values or categorical descriptors based on the complexity and presence of features in each building. Scores were compiled based on the coded metrics, allowing for quantitative comparison between the Seljuk and Byzantine architectural traditions.

• Comparison and Visualization: The final step involved visualizing the comparative data using charts and tables to highlight the differences and similarities between the two traditions.

Figure 1. Methodology of research on comparative Analysis of art and technology in Seljuk and Byzantine Architecture, Source: Authors..

Overview of the Seljuk and Byzantine Paradigms in Anatolian Architecture

The architectural traditions of both the Seljuk and Byzantine empires developed within a shared historical and geographical context, yet their distinct religious beliefs, political objectives, and available resources gave rise to unique architectural paradigms. As Hillenbrand (2004) argues in Islamic Architecture, the Seljuks, influenced by Persian and early Islamic art, emphasized adaptability and ornamentation, evident in their use of intricate geometric patterns, calligraphy, and muqarnas. This decorative focus is contrasts with Byzantine architecture, as explored by Mango (1985) in The Art of the Byzantine Empire, which emphasized monumental scale and technical mastery, particularly in dome construction and the use of stone. The Byzantines relied heavily on mosaics and figurative representation to convey religious narratives, as seen in iconic structures like Hagia Sophia. In contrast, Seljuk architecture, as highlighted by Ettinghausen et al. (2003) in Islamic Art and Architecture, reflects Islamic principles of unity and symmetry through its decorative elements and structural techniques. This interaction between the two traditions, particularly in Anatolia, fostered a dynamic exchange of architectural innovations while preserving the distinct identities of each empire.

Feature	Seljuk	Byzantine
Dominant Artistic Style	Intricate geometric patterns, calligraphy, stylized floral motifs, and prominent use of muqarnas.	Mosaics, figurative representations, classical-inspired floral motifs, and limited use of geometric patterns.
Religious Context	Islamic principles of unity, harmony, and the beauty of creation.	Eastern Orthodox Christianity, emphasizing religious iconography and narratives.
Political Context	Expanding Seljuk Sultanate seeking to solidify power and establish a distinct cultural identity.	Byzantine Empire maintaining imperial authority and cultural dominance while facing external pressures.
Structural Emphasis	Adaptable construction using brick, seamlessly integrating ornamentation with structure.	Technical mastery with a focus on sophisticated stone construction techniques.
Dome Construction	Squinch arches, brick, creating a lighter and more airy aesthetic.	Pendentives, stone, creating a more imposing and massive scale.
Vaulting Systems	Ribbed vaults, creating intimate interior spaces.	Barrel and groin vaults, emphasizing spaciousness and grandeur.
Decorative Elements	Geometric patterns, calligraphy, floral motifs, and muqarnas reflecting Islamic principles.	Mosaics, frescoes, and classical-inspired motifs reflecting religious narratives and imperial power.
Overall Aesthetic	Harmonious unity, intricate ornamentation often concealing structural framework.	Grandeur and awe-inspiring scale, emphasizing visible structural mastery.
Influence in Anatolia	Shaped later Anatolian styles, particularly Ottoman architecture.	Left a legacy on architectural techniques, especially in dome construction and stonework.

Table 2. Overview of the Seljuk and Byzantine Paradigms in Anatolian Architecture, Source: Authors.

Selecting Case Studies

The primary objective of this step is to select representative buildings from both Seljuk and Byzantine architectural traditions that offer a rich basis for comparative analysis.

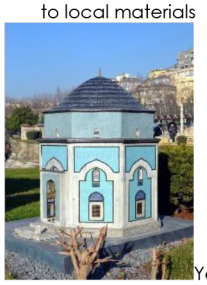
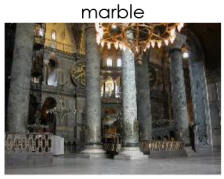
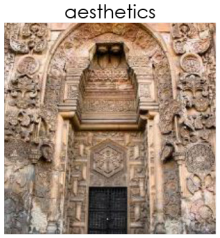
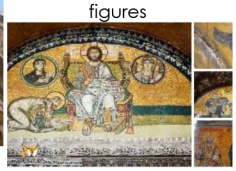
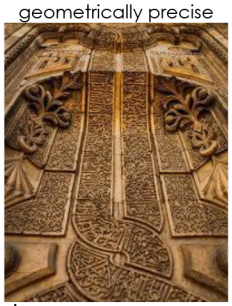
Buildings were selected based on their historical and architectural significance within each tradition. To ensure a comprehensive comparison, buildings of different functions (e.g., mosques, churches, tombs, palaces) were chosen. This allows for the evaluation of a wide range of architectural expressions and innovations within each tradition that represent the core characteristics of Seljuk and Byzantine architecture, enabling a detailed comparative analysis.

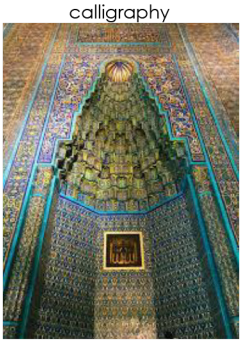
The comparative analysis of Seljuk and Byzantine architecture in Anatolia reveals distinct approaches to both structural technologies and decorative elements, reflecting the cultural, religious, and technical priorities of each empire. While both traditions coexisted in the same region, their architectural features illustrate different design philosophies. The Seljuk style is characterized by an emphasis on intricate ornamentation, adaptability in the use of materials, and a focus on geometric precision, often incorporating Islamic symbolism. In contrast, Byzantine architecture is known for its monumental scale, mastery of stone construction, and the extensive use of religious imagery through mosaics and structural visibility. By examining features such as dome construction, vaulting systems, materials, and decorative techniques, scholars can gain insights into how these empires shaped the architectural landscape of Anatolia. Table 4 provides a detailed breakdown of the key structural and decorative elements of both Seljuk and Byzantine architecture, with examples from iconic Anatolian structures.

Table 3. Overview of the Seljuk and Byzantine Paradigms in Anatolian Architecture, Source: Authors.

Case Study	Style	Key Structural Features	Key Decorative Elements	Cultural & Historical Significance
Great Mosque of Divriği, Divriği, Türkiye, 1228-1229	Seljuk	Dome supported by squinch arches Combination of stone construction Complex vaulting system Use of buttresses for support	Elaborate geometric patterns Intricate stone carvings Floral motifs and Quranic inscriptions in calligraphy	Represents the synthesis of Seljuk and Byzantine influences A UNESCO World Heritage Site Demonstrates Seljuk architectural skill Blends religious and secular elements
Green Mosque, Bursa, Türkiye, 1421	Seljuk	Dome supported by squinch arches Brick construction with glazed tile decoration Use of muqarnas for both decorative and structural support	Intricate geometric patterns throughout Richly coloured glazed tiles Calligraphic inscriptions on the walls and ceilings	Illustrates the peak of Seljuk architecture Commissioned by Sultan Mehmed I Symbol of Ottoman architectural tradition influenced by Seljuk art and techniques
Sultanhani Caravanserai, 1229	Seljuk	Ribbed vaulting systems Brick construction with expansive courtyard Functional design with large entrance iwan	Use of geometric patterns in stonework Calligraphic inscriptions and ornamentation in the main hall	Largest and best-preserved Seljuk caravanserai along the Silk Road Showcases Seljuk advancements in functional architecture with decorative integration
İnce Minareli Madrasa, Konya, Türkiye, 1260s	Seljuk	Towering minaret with ribbed construction Stone masonry Combination of educational and religious functions	Elaborate stone carvings Calligraphic decoration along the minaret Geometric patterns and inscriptions	A key example of Seljuk educational institutions Blends religious and educational architecture Known for its ornamentation and functional design
Yeşil Türbe (Green Tomb), Bursa, Türkiye, 1421-1422	Seljuk	Dome supported by squinch arches Brick construction with tiled exterior Harmonious design with elegant proportions	Richly coloured glazed tiles Intricate geometric patterns and floral motifs Extensive use of calligraphy Muqarnas decoration	Commissioned by Sultan Mehmed I Exquisite ornamentation and harmonious design Represents the influence of Seljuk architecture on early Ottoman tradition
Hagia Sophia, Istanbul, Türkiye, 537	Byzantine	Massive dome supported by pendentives Extensive stone construction Complex vaulting system Use of buttresses to support the dome	Mosaics depicting religious and imperial figures Marble columns and pilasters Intricate geometric patterns in the mosaics	A masterpiece of Byzantine architecture Symbol of Byzantine imperial power A UNESCO World Heritage Site Reflects the cultural and religious significance of Constantinople
Church of the Holy Apostles, Istanbul, Türkiye, 532-547	Byzantine	Dome supported by pendentives Stone construction with marble columns Cross-in-square layout Barrel and groin vaulting systems	Mosaic decoration with biblical and imperial themes Marble columns Geometric patterns in the mosaics	One of the most impressive churches of the Byzantine Empire Reflects the wealth and power of Byzantium Represents the use of architecture for religious and political purposes
Hagia Irene, Istanbul, Türkiye, 7th century	Byzantine	Dome supported by squinch arches Stone construction with marble columns Barrel vaults and groin vaults Emphasis on structural expression	Mosaics with religious themes Marble columns Intricate geometric patterns in mosaics Decorated interior spaces	Early example of Byzantine church architecture Prime example of vaulting techniques Symbol of Constantinople's artistic legacy
Monastery of Hosios Loukas, Boeotia, Greece, 10th century	Byzantine	Domed cross-in-square design Stone and brick construction Use of barrel and groin vaults	Elaborate mosaic work with religious themes Use of marble columns and decorative elements Geometric and floral motifs	Represents Middle Byzantine ecclesiastical architecture Blend of structural ingenuity and artistic expression Key example of religious architecture in Greece
Chora Church, Istanbul, Türkiye, 11th century	Byzantine	Smaller domed structure supported by arches Stone construction with complex vaulting systems Integration of architectural elements with the surrounding space	Famous for its preserved mosaics and frescoes Naturalistic floral motifs Geometric patterns in mosaics Richly decorated interior spaces	Late Byzantine architecture Illustrates the artistic achievements of the period Well-known for its preserved mosaics and frescoes

Table 4. Case Studies: Seljuk and Byzantine Architecture in Anatolia, source: Authors

		Dome Construction		Vaulting Systems	
		Seljuk	**Byzantine**	**Seljuk**	**Byzantine**
Structural Technologies		Squinch arches; use of brick and glazed tiles  Green Mosque, Bursa (dome supported by squinch arches, glazed tiles)	Pendentives; use of stone and marble  Hagia Sophia, Istanbul (massive dome supported by pendentives, stone construction)	Ribbed vaults, more intimate interior spaces  Sultanhani Caravanserai (ribbed vaults for structural support)	Barrel and groin vaults, creating grand interiors  Hagia Irene, Istanbul (barrel vaults, grand spaces)
		Materials & Techniques		**Structural Expression**	
		Primarily brick; adaptable to local materials  Yeşil Türbe, Bursa (brick construction, intricate decoration)	Predominantly stone, skilled masonry with marble  Church of the Holy Apostles (stone, marble columns, monumental design)	Concealed structural elements, focus on aesthetics  Great Mosque of Divriği (brick and stone, smooth exterior with ornamentation)	Visible structural elements, emphasis on mastery  Hagia Sophia, Istanbul (visible arches and dome, emphasizing structural strength)
Decorative Elements		**Mosaics**	**Muqarnas**		
		Limited use, mostly geometric designs  Sultanhani Caravanserai (small geometric mosaics)	Extensive use, religious and imperial themes, figures  Hagia Sophia, Istanbul (religious figures and imperial imagery)	Prominent feature, both structural and decorative  Mausoleum of Sultan Mehmed I, Bursa (intricate muqarnas)	Limited, mainly for decorative purposes  Chora Church, Istanbul (limited use of muqarnas)
		Floral Motifs	**Calligraphy**		
		Stylized, symmetrical, and geometrically precise  İnce Minareli Madrasa, Konya (stylized floral motifs)	Naturalistic, often more free flowing  Hagia Sophia, Istanbul (naturalistic floral motifs)	Prominent, often integrated with geometric designs, Quranic inscriptions  Yeşil Türbe, Bursa (Quranic inscriptions)	Limited, mostly for inscriptions  Hagia Sophia, Istanbul (minimal use of calligraphy, mainly inscriptions)

Geometric Patterns	
Highly intricate, Islamic mathematical principles, often integrated with calligraphy	Simpler geometric patterns, used mostly for decoration
 Green Mosque, Bursa (interlacing patterns, calligraphic integration)	 Chora Church, Istanbul (simpler geometric patterns within mosaics)

Define Key Metrics

To develop measurable criteria for the architectural features to be analyzed in the case studies, we defined metrics that are applied consistently across the selected case studies, allowing for a systematic comparison of architectural features.

- Structural Technologies: Metrics for structural elements such as dome construction, vaulting systems, and material innovations were defined. For instance, dome complexity is assessed based on size, support mechanisms (e.g., pendentives or squinches), and structural innovations.

- Decorative Elements: Metrics were also established for decorative features, such as the presence of mosaics, geometric patterns, floral motifs, and calligraphy. These metrics allow for an analysis of how decorative elements reflect religious, cultural, and political values.

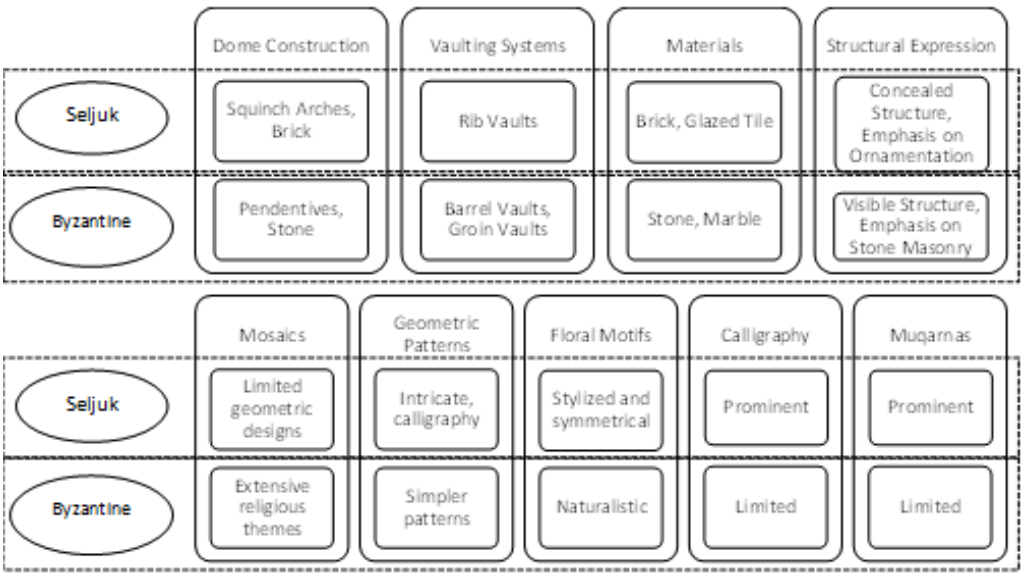


Figure 2. Comparative Analysis of Structural Technologies and Decorative Elements in Seljuk and Byzantine Architecture (Anatolian Focus), source: Authors.

Establish a Coding System and Quantitative Scoring

To ensure consistency in evaluating the selected buildings, a coding system was developed to quantify architectural features based on defined metrics.

Numerical Coding: Architectural features such as dome complexity were assigned numerical values:

- Simple dome with minimal support.
- Moderate complexity with elements like pendentives or squinches.
- Highly complex domes with multiple support mechanisms.

Categorical Coding: Decorative elements, such as mosaics, were rated based on presence or complexity (1 for simple mosaics, 5 for intricate mosaics).

Metric	Feature Description	Seljuk Example	Seljuk Score	Byzantine Example	Byzantine Score
Dome Construction					
Dome Support Mechanism	1 = Pendentive, 2 = Squinch Arch	Green Mosque	2	Hagia Sophia	1
Material Used	1 = Stone, 2 = Brick	Green Mosque	2	Hagia Sophia	1
Size of Dome (m)	Measured diameter				
Transition Type	1 = Direct, 2 = Layered	Green Mosque	2	Hagia Sophia	1
Vaulting Systems					
Type of Vault	1 = Barrel, 2 = Groin, 3 = Ribbed	Sultanhani Caravanserai	3	Hagia Irene	1
Vault Span (m)	Measured span				
Number of Vaults	Count of vaults	5	5	Hagia Irene	3
Aesthetic Integration	1 = Exposed, 2 = Concealed	Sultanhani Caravanserai	2	Hagia Irene	1
Materials & Techniques					
Primary Material	1 = Stone, 2 = Brick	Sultanhani Caravanserai	2	Hagia Sophia	1
Masonry Techniques	1 = Plain, 2 = Decorative, 3 = Intricate	İnce Minareli Madrasa	3	Hagia Sophia	2
Decorative Material	1 = Glazed Tile, 2 = Stone, 3 = Marble	Green Mosque	1	Hagia Sophia	3
Structural Expression					
Visibility of Structure	1 = Visible, 2 = Concealed	İnce Minareli Madrasa	2	Hagia Sophia	1
Decorative Focus	1 = Technical/Structural, 2 = Aesthetic	Green Mosque	2	Hagia Sophia	1
Decorative Elements					
Presence of Mosaics	1 = Yes, 0 = No	Green Mosque	0	Hagia Sophia	1
Dominant Theme	1 = Geometric, 2 = Religious, 3 = Floral	İnce Minareli Madrasa	1	Hagia Sophia	2
Scale of Mosaics	1 = Small, 2 = Medium, 3 = Large	Green Mosque	1	Hagia Sophia	3
Complexity of Patterns	1 = Simple, 2 = Intermediate, 3 = Complex	İnce Minareli Madrasa	3	Hagia Sophia	2
Integration with Calligraphy	1 = Yes, 0 = No	İnce Minareli Madrasa	1	Hagia Sophia	0
Style of Floral Motifs	1 = Naturalistic, 2 = Stylized, 3 = Geometric	Green Mosque	2	Chora Church	1
Symmetry of Floral Motifs	1 = Symmetrical, 2 = Asymmetrical	Green Mosque	1	Chora Church	2
Presence of Calligraphy	1 = Yes, 0 = No	İnce Minareli Madrasa	1	Hagia Sophia	0
Type of Calligraphy	1 = Quranic, 2 = Decorative, 3 = Both	İnce Minareli Madrasa	1	Hagia Sophia	0
Presence of Muqarnas	1 = Yes, 0 = No	Green Mosque	1	Hagia Sophia	0
Purpose of Muqarnas	1 = Decorative, 2 = Structural	Green Mosque	1	Hagia Sophia	0

Table 5. Analysing Structural and Decorative Elements in Seljuk and Byzantine Architecture (Anatolian Focus), Source: Authors.

Quantitative Scoring and Analysis

To apply the coding system was applıed to compare Seljuk and Byzantine architectural features. Each building was evaluated and assigned scores based on the coding system. Scores for key features like dome complexity, vaulting systems, and decorative richness were calculated for each building. Scores were compared between Seljuk and Byzantine buildings to highlight differences in architectural innovations. A set of quantitative data was generated, providing an objective basis for comparing structural and decorative features of the Seljuk and Byzantine buildings. Table 5 is based on the named case studies and incorporates Seljuk and Byzantine examples discussed earlier.

Comparison and Visualization

We used charts and graphs to visualize the comparative data, highlighting key differences and similarities between the Seljuk and Byzantine architectural traditions. Bar charts, tables, and heat maps were created to compare architectural scores across the key metrics. For instance, a bar chart was used to display the average decorative richness scores for Seljuk and Byzantine buildings. Visual aids were used to highlight trends in architectural practices, such as differences in dome construction methods or decorative elements between the two traditions. The visualized data clearly illustrates the architectural distinctions between Seljuk and Byzantine buildings, making it easier to interpret the comparative results.

Table 6. Comparative Analysis of Seljuk and Byzantine Architectural Features, Source: Authors.

Metric	Seljuk Score	Byzantine Score
Dome Support Mechanism	2	1
Material Used	2	1
Size of Dome (scale 1 per 10 m)	1	3
Transition Type	2	1
Type of Vault	3	1
Vault Span (scale 1 per 10 m)	1	2
Number of Vaults per Building	5	3
Aesthetic Integration	2	1
Primary Material	2	1
Masonry Techniques	3	2
Decorative Material	1	3
Visibility of Structure	2	1
Decorative Focus	2	1
Presence of Mosaics	0	1
Dominant Theme	1	2
Scale of Mosaics	1	3
Complexity of Patterns	3	2
Integration with Calligraphy	1	0
Style of Floral Motifs	2	1
Symmetry of Floral Motifs	1	2
Presence of Calligraphy	1	0
Type of Calligraphy	1	0
Presence of Muqarnas	1	0
Purpose of Muqarnas	1	0

The following chart (Figure 3) visually represents the quantitative comparison of Seljuk and Byzantine architectural features across metrics such as dome support mechanisms, vaulting systems, materials, and decorative elements.

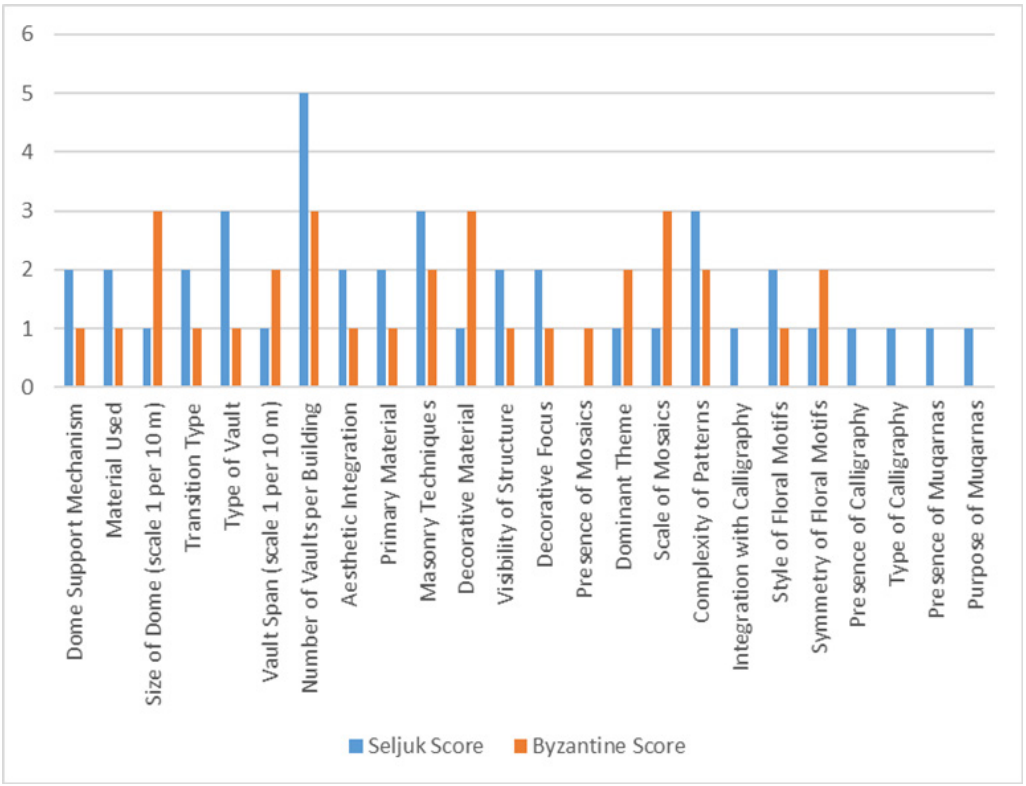


Figure 3. Metric-Based Comparative Analysis of Seljuk and Byzantine Architectural Practices in Medieval Anatolia, Source: Authors.

DISCUSSION

The comparison of Seljuk and Byzantine architectural styles reveals fascinating differences in their priorities and approaches, shaped by the cultural and practical needs of their time. Seljuk buildings, such as the Green Mosque, showcase an inventive and adaptable style, often using squinch arches and incorporating locally available materials like brick and glazed tiles. These choices allowed Seljuk architects to create intricate designs that were both visually striking and functional. On the other hand, Byzantine structures, exemplified by the Hagia Sophia, emphasized permanence and grandeur through the use of stone and marble, with domes supported by advanced pendentive systems that conveyed a sense of monumental scale.

The vaulting systems of these traditions also highlight their contrasting philosophies. The Sultanhani Caravanserai's ribbed vaults reflect the Seljuk focus on creating intimate, utilitarian spaces, while Byzantine buildings like Hagia Irene employed barrel and groin vaults to craft expansive, awe-inspiring interiors. This difference in approach illustrates how each culture adapted its architecture to reflect its values and priorities.

In terms of decoration, Seljuk architects excelled at creating geometric patterns and incorporating calligraphy, producing works of exceptional intricacy, as seen in the İnce Minareli Madrasa. Byzantine architecture, however, prioritized rich mosaics and figurative representations that conveyed powerful religious narratives, most famously in the Hagia Sophia's detailed interiors.

Even the treatment of structural elements speaks to their distinct identities. Seljuk structures, like the Great Mosque of Divriği, often concealed their structural

frameworks, achieving a harmonious blend of form and ornamentation. Byzantine buildings, by contrast, celebrated their engineering feats, prominently displaying the complexity of their structural designs to inspire reverence.

These architectural differences reflect the diverse cultural, religious, and technological influences that shaped medieval Anatolia. Together, they contribute to a rich architectural heritage, offering insights into how two distinct traditions coexisted and left their mark on history.

Figure 4 highlights the contrasting priorities in architectural techniques and decoration between the Seljuk and Byzantine styles, illustrating how each tradition achieved a unique harmony between artistic expression and the practical demands of structural design.

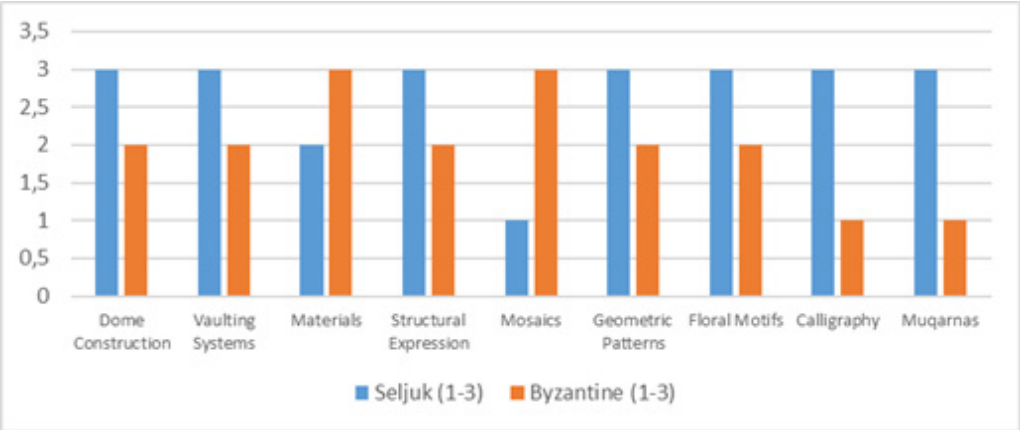


Figure 4. Comparative Analysis of art and technology in Seljuk and Byzantine Architecture, Source: Authors.

CONCLUSION

This study has explored the intricate interplay between Seljuk and Byzantine architectural traditions, shedding light on how these two distinct yet overlapping styles coexisted and evolved in medieval Anatolia. While structural techniques were shared and adapted across cultural boundaries, decorative and symbolic elements retained their uniqueness, reflecting the divergent religious and artistic ideologies of each tradition. The Seljuk focus on ornamentation, geometric precision, and Islamic symbolism stands in contrast to the Byzantine emphasis on structural grandeur, religious iconography, and monumental stonework. Together, these approaches shaped a distinctive Anatolian architectural identity that harmonized technological innovation with artistic creativity.

The comparative analysis highlights the different architectural priorities of the Seljuk and Byzantine traditions. The Seljuks preferred lightweight brick structures adorned with intricate calligraphy and muqarnas, showcasing an adaptability to local materials and an emphasis on decorative detail. In contrast, Byzantine architects employed monumental stone construction, integrating religious figural mosaics and imposing structural elements to convey imperial and spiritual power. These contrasting priorities reflect the broader cultural, religious, and political contexts that influenced each empire's architectural choices.

By defining key structural and decorative elements—such as dome construction, vaulting systems, geometric patterns, and the use of calligraphy and mosaics—this study offers a systematic framework for analyzing the architectural legacy of both traditions. This framework not only enhances scholarly understanding but also emphasizes the dynamic cultural exchanges that the architectural heritage of Anatolia. The findings underscore how architecture serves as a medium of

cross-cultural dialogue, shaping identities and inspiring future developments in the region.

Conflict of Interest

No conflict of interest was declared by the authors.

Authors' Contributions

The authors contributed equally to the study.

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REFERENCES

Ashkan, M., & Ahmad, Y. (2012). Significance of conical and polyhedral domes in Persia and surrounding areas: Morphology, typologies, and geometric characteristics. *Nexus Network Journal, 14*(2), 275–290. https://doi.org/10.1007/s00004-012-0112-x

Azarpay, G. (1982). The Islamic tomb tower: A note on its genesis and significance. In A. Daneshvari (Ed.), *Essays in Islamic art and architecture in honor of Katharina Otto-Dorn* (pp. 9–12). Undena Publications.

Blair, S. (2008). *Islamic calligraphy*. Edinburgh University Press.

Blair, S. S., & Bloom, J. M. (1994). *The art and architecture of Islam, 1250–1800*. Yale University Press.

Blessing, P. (2014). *Rebuilding Anatolia after the Mongol conquest: Islamic architecture in the lands of Rūm, 1240–1330*. Ashgate Publishing.

Ettinghausen, R., Grabar, O., & Madina, M. J. (2003). *Islamic art & architecture, 650–1250*. Yale University Press.

Grabar, A. (1967). The art of the Byzantine Empire: Byzantine art in the Middle Ages. Crown Publishers.

Grube, E. J., & Michell, G. (1995). *Architecture of the Islamic world: Its history and social meaning*. Thames & Hudson.

Gülru, N. (2008). *The age of Sinan: Architectural culture in the Ottoman Empire*. Reaktion Books.

Hill, D. R., & Al-Hassan, A. Y. (1992). *Islamic technology: An illustrated history*. Cambridge University Press.

Hillenbrand, R. (2004). *Islamic architecture*. Edinburgh University Press.

Hillenbrand, R. (2010). Islamic art and architecture. In F. B. Flood & G. Necipoğlu (Eds.), *The Oxford handbook of Islamic art and architecture* (pp. 1–24). Oxford University Press.

Mainstone, R. J. (1997). *Hagia Sophia: Architecture, structure, and liturgy of Justinian's great church*. Thames & Hudson.

Mango, C. (1985). *Byzantine architecture*. Electa Editrice Press.

Mosavi, Z. (2002). Mogharnas in architecture. *Ketab-e Mah-e Honar, 348,* 45–46.

Nazer, Z., Belali Oskoui, A., & Keynejad, M. A. (2016). A study of transparency behavior of domes in Islamic mosques with emphasis on the notion of the spiritual lighting. *Journal of Research in Islamic Architecture, 4*(3), 94–112. http://jria.iust.ac.ir/article-1-549-en.html

Nazer, Z., Kovács, G. M., & Rabb, P. (2020). Comprehensive revelation on the tomb towers architecture; Persia and Anatolia. *ICONARP International Journal of Architecture and Planning, 8*(2), 801–820. https://doi.org/10.15320/ICONARP.2020.137

Necipoğlu, G. (1995). *The Topkapi scroll: Geometry and ornament in Islamic architecture*. Getty Publications.

Önkal, H. (1996). Anadolu Selçuklu Türbeleri. Atatürk Kültür Merkezi Yayınevi.

Ousterhout, R. G. (2019). *Eastern medieval architecture: The building traditions of Byzantium and neighboring lands.* Oxford University Press.

Pope, A. U., & Ackerman, P. (1981). *A Survey of Persian art from prehistoric times to the present.* Maxwell Aley Literary Associates.

Redford, S. (1993). The Seljuks of Rum and the antique. Muqarnas, 10, 148–156.

Schroeder, E. (1938). Islamic architecture: Seljuq period. In A. U. Pope & P. Ackerman (Eds.), *A survey of Persian art* (pp. 930–966). Oxford Press.

Tabbaa, Y. (1997). *The transformation of Islamic art during the Sunni revival.* University of Washington Press.

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