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Archival Data and Engineering Analysis of the Oq Mosque in the City of Khiva

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Abstract: The White Mosque (Oq Masjid) in Khiva, constructed between 1838–1842, represents a vital example of Uzbekistan's architectural heritage, reflecting the cultural and historical identity of the region. This study addresses the urgent need to assess and enhance the earthquake resilience of such historical structures due to their vulnerability to natural degradation and seismic activity. A key knowledge gap lies in the lack of systematic engineering assessments and restoration frameworks tailored to historic monuments like Oq Masjid. The research utilizes engineering diagnostics, including structural measurements and seismic resilience evaluations, to analyze the mosque's architectural integrity. Findings reveal specific structural vulnerabilities, such as termite damage in wooden elements and fissures in the dome, which compromise the mosque's stability. The results underscore the importance of targeted retrofitting using modern engineering tools while preserving historical authenticity. The study implies that accurate assessment of historical structures' technical condition is critical for their preservation and proposes that urgent reinforcement, especially of minarets, is needed to prevent further deterioration. This research contributes to the broader discourse on safeguarding architectural heritage in seismically active regions.

Keywords: Khiva, White Mosque, architectural monument, seismic resistance, structural analysis, restoration, heritage conservation.

INTRODUCTION

Architectural monuments serve not only as cultural landmarks but also as tangible embodiments of a nation's history, artistic achievements, and technological progress. In Uzbekistan, especially in historical cities like Khiva, ancient structures such as the White Mosque (Oq Masjid) play a central role in preserving the country's cultural identity. These monuments are critical to national heritage, tourism, and the education of future generations. However, they are increasingly threatened by environmental degradation and seismic activity, making their structural assessment and preservation an urgent necessity[1].

Among the various architectural structures in Khiva, the Oq Masjid is distinguished by its symmetrical square design, distinctive dome structure, and culturally embedded wooden elements. The mosque exemplifies the integration of Central Asian architectural traditions with

functional religious design. Recent urban development and natural factors, particularly earthquakes, have posed severe challenges to its structural integrity. Despite its historical value, systematic studies on the mosque's engineering condition, especially concerning earthquake resilience, remain limited. This gap underscores the need for focused structural and seismic research on heritage buildings[2][3].

Several scholars, including Shadmanova et al., have examined the general features and seismic issues of historical structures in Uzbekistan. While these studies provide foundational insights into architectural conservation, they often lack in-depth, site-specific engineering assessments[4]. Moreover, prior literature has not adequately addressed the biological and seismic threats to wooden elements, particularly in monuments like the Oq Masjid, which utilize both brick and timber in their design. Thus, there is a compelling need to bridge this knowledge gap with targeted diagnostics and preservation planning[5].

This study employs a combination of on-site structural inspections, dimensional analysis, and seismic vulnerability assessments using technical measurement tools. The methodology includes evaluating the condition of foundational elements, analyzing dome and minaret stability, and identifying bio-deterioration risks such as termite damage. These evaluations aim to develop practical recommendations for enhancing the mosque's seismic resilience while preserving its architectural authenticity[6].

The findings suggest that although the Oq Masjid retains much of its original structural charm, significant interventions are required to prevent further degradation. Cracks in the dome, termite-infested wood, and minaret instability point to a critical need for immediate reinforcement measures. These results have important implications for national heritage policy, proposing a model for the preservation of similar monuments in seismic regions. The study not only fills an essential gap in the architectural conservation literature but also contributes actionable insights for engineers, conservationists, and policymakers engaged in the protection of historical buildings in Central Asia[7].

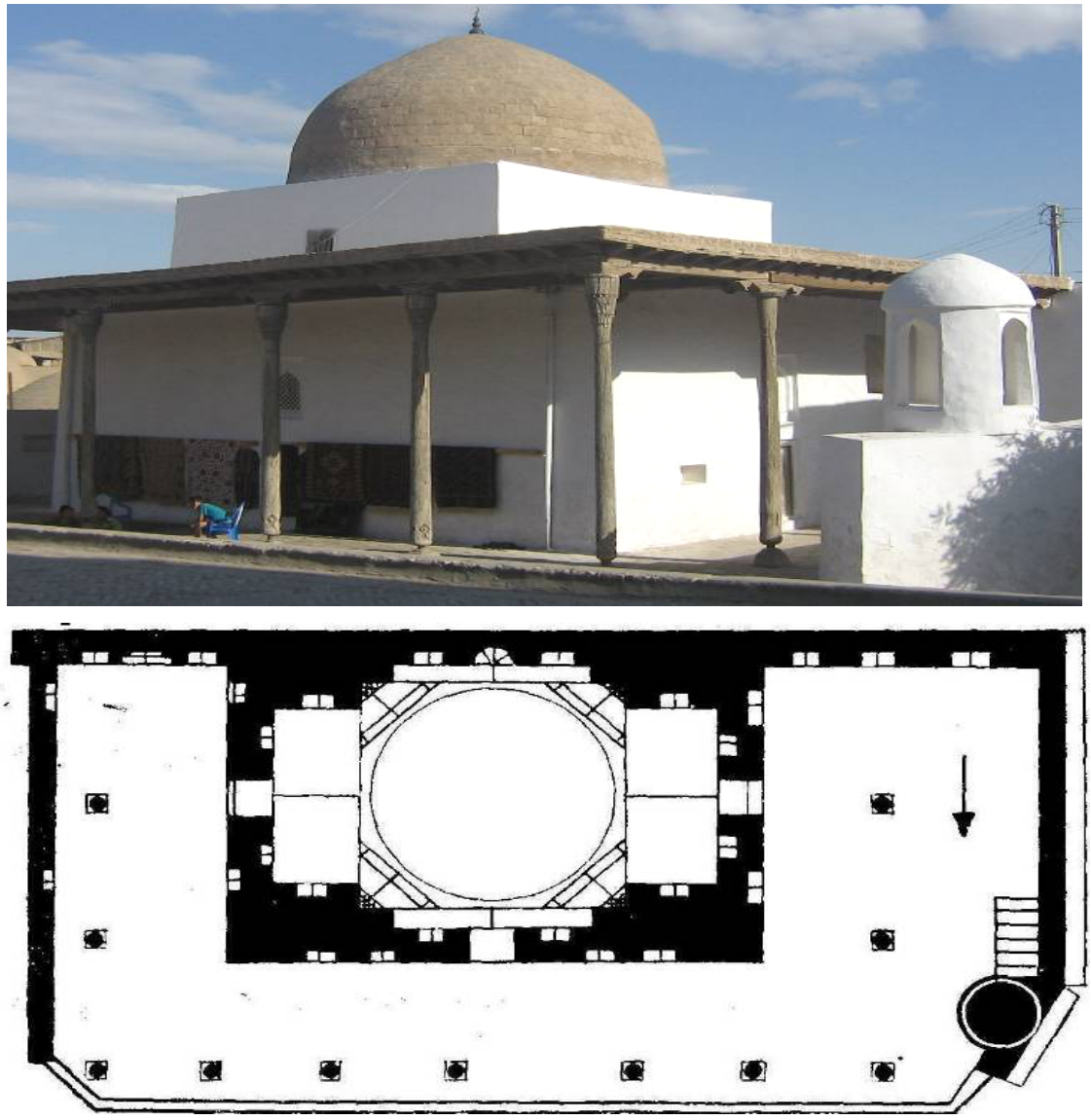
Methodology

The methodology adopted in this study focuses on a detailed architectural and engineering analysis of the White Mosque (Oq Masjid) located in the eastern part of Ichan-Qala in Khiva. The research was conducted through a combination of historical review, direct site observation, technical measurement, and structural diagnostics. Initially, historical data and previous scholarly works on Central Asian architecture were reviewed to contextualize the mosque's construction within the broader tradition of Islamic architecture in Uzbekistan. Fieldwork involved the physical examination of the mosque's structural layout, including its foundations, walls, dome, columns, and wooden elements. Accurate measurements were taken to assess the mosque's dimensions, which include a total structure size of 25.5 x 13.5 meters, with the prayer hall measuring 13.0 x 9.5 meters and a dome height of 12.3 meters. The diagnostic process included visual inspection for visible damage, such as cracks, deformations, and signs of biological deterioration—specifically termite infestation in wooden parts. Additionally, dynamic characteristics of the structure were examined using specialized equipment to determine the resilience of various components under seismic conditions. The stability and load-bearing performance of the dome and minaret were analyzed, considering both historical construction methods and modern seismic safety requirements. Comparative analysis with international restoration practices and Uzbekistan's construction norms provided a framework for assessing structural risks. This comprehensive methodological approach enabled the identification of vulnerabilities and the proposal of scientifically grounded, preservation-oriented recommendations to ensure the mosque's structural longevity and seismic safety.

Results and Discussion

The structural and architectural investigation of the White Mosque (Oq Masjid) in Khiva has revealed critical findings related to its current physical state and long-term preservation needs.

The mosque's traditional Central Asian architectural layout, particularly its symmetrical plan and three-sided ayvan (portico), contributes to its historical significance and functional design. Dimensional analysis confirmed the structural logic behind its layout, where the square prayer hall (6.35 x 6.35 m) supports a dome with a 9.35 m diameter, emphasizing spatial centrality and geometric balance. However, visual inspections and diagnostic surveys uncovered multiple forms of degradation. Notably, biological deterioration in the form of termite damage was detected in wooden columns, a common issue in historical Khivan architecture. Structural cracks along the dome and western walls further indicated seismic vulnerability.



1 - rasm. Oq masjid yodgorligi va uning tarhi.

The mosque's deep foundation, extending up to 4 meters, appears to be a positive factor for seismic resistance; however, the absence of retrofitted elements or reinforcement systems reflects a significant preservation gap. The degradation of structural joints and erosion of decorative elements highlight the need for urgent conservation interventions. Despite the mosque's resilience, the absence of a comprehensive seismic retrofitting strategy presents a critical knowledge gap, as there is limited literature or policy guidance on practical conservation of wooden structural elements in seismic zones of Central Asia. This underscores the necessity for advanced interdisciplinary research combining seismology, materials science, and conservation engineering to develop sustainable reinforcement strategies.

The findings from this study emphasize the duality of the Oq Masjid as both a cultural artifact and a functional structure. Its survival depends not only on aesthetic preservation but also on the

strengthening of its engineering integrity. In terms of practical implications, the research suggests the implementation of lightweight, non-invasive reinforcement techniques for domes and wooden supports. The technical assessment of the mosque's structural behavior under potential seismic loads remains an area for deeper investigation using simulation-based methods and material testing.

Moreover, future studies should focus on comparative evaluations with similar mosques in other seismically active heritage zones, integrating geographic information systems (GIS) and structural health monitoring (SHM) tools. These advancements could lead to the development of national restoration protocols specific to Islamic architecture in Uzbekistan. In conclusion, this research not only highlights the urgent preservation needs of the Oq Masjid but also contributes to a growing body of theoretical and applied knowledge on architectural heritage conservation in earthquake-prone areas. Bridging this gap will require continued collaboration among architects, engineers, historians, and policymakers to ensure that monuments like the Oq Masjid endure for future generations.

CONCLUSION

In conclusion, the structural assessment of the White Mosque (Oq Masjid) in Khiva has revealed both its architectural significance and pressing vulnerabilities, particularly in relation to seismic resilience and biological degradation of its wooden components. The study highlighted the mosque's distinct spatial organization, deep foundation, and traditional design elements, which contribute to its historical and functional value. However, the presence of cracks in the dome, termite damage, and signs of structural fatigue underscore the urgent need for targeted conservation efforts. These findings imply that without timely intervention and the application of modern yet culturally sensitive restoration methods, the longevity of such heritage monuments remains at risk. The implications extend beyond the Oq Masjid, emphasizing the necessity for a broader preservation strategy for similar structures across Uzbekistan's seismically active regions. Further research should prioritize interdisciplinary collaboration to develop retrofitting techniques that align with both historical authenticity and structural safety. Advanced studies incorporating seismic modeling, material science, and digital monitoring technologies are essential to formulate effective, replicable restoration frameworks that can safeguard Uzbekistan's architectural heritage for future generations.

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