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Research Paper

Structural Assessment of the Archaeological Areas in Al-MadinahRegion: A Case Study of Al-Tawbah Mosque

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ABSTRACT: *This research assesses the structural status of historical sites in the Al-Madinah region, with a focus on the Al-Tawbah Mosque as a case study. The goal of this project is to examine the preservation and repair needs of historic sites through engineering analysis and community participation. The research technique includes field surveys, data collection, and engineering analysis. Field studies describe the current condition of historical sites, noting structural integrity, deterioration regions, and causes that contribute to degradation. Data collection comprises accumulating historical information, architectural blueprints, and previous research works in order to comprehend the original design, building techniques, and historical relevance. Non-destructive testing processes are used in engineering studies to evaluate structure stability, material condition, and potential hazards. The findings show the current state of the historical site, highlighting specific issues such as deterioration and fragility. The team will study the mosque's structural integrity, detect damage, and evaluate degradation to determine repair feasibility, resources, timelines, and costs. The project's purpose is to restore the mosque's prior historical identity while keeping in mind its relevance, usefulness, and value to the community and the cultural identity of Al-Madinah.*
KEYWORDS: *Repair, Heritage, Rehabilitation, Historical Buildings, Al-Madinah.*

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I. INTRODUCTION

Historical buildings are considered to be an important element in expressing the identity and culture of any country, because they express the outcome of the accumulation that occurred in urbanization and the extent of its development throughout history. In the context of talking about historical buildings, the Kingdom of Saudi Arabia has a full record of historical buildings with a long heritage, especially those that reflect the Islamic heritage since the dawn of the first Islamic state and its capital, Al-Medina. As Al-Medina is considered one of the most cities in the Kingdom full of historical places, specifically places associated with the biography of the Prophet Muhammad peace be upon him, including the mosques that the Prophet Muhammad peace be upon him prayed on them during his immigration from Makkah to Al-Medina. One of those mosques in which the Prophet prayed during his immigration is called the Al-Tawbah Mosque, where this mosque receives the attention of all visitors coming to the Al-Medina. Hence, the Saudi Commission for Tourism and Antiquities is keen to preserve these antiquities by rehabilitating them to preserve the biography of the Prophet Muhammad, peace be upon him and, also as part of the efforts aimed at revitalizing tourism.

Al-Tawbah Mosque is located inside a farm in Al-Usbah district, close to the well of Al-Hajim to the southwest of Quba mosque, in Al-Madinah Al-Munawara region. It is also known as Al-Nour Mosque and due to the mosque is located inside Al-Usbah district it is also referred to as Al-Usbah mosque. The mosque has a total gross area of 121 m^2. According to some resources the age of this mosque is approximately 1446 years which means that the mosque was built before the arrival of the Prophet, peace be upon him, to Al-Medina, and it is considered one of the historical mosques that has great importance, since the immigrants used to pray there when they reached Medina. Also, when the Prophet Muhammad, peace be upon him, during his blessed immigration trip from Makkah to Al-Medina passed through this mosque and prayed in it, therefore it is considered one of the crucial places for Muslims. This project aims to highlight Al-Tawbah Mosque by assessing its structural condition and then innovating methods and solutions to rehabilitate the mosque.

II. REHABILITATION OF THE MOSQUE

The mosque has been restored and repaired many times. However, there are two well-known rehabilitation periods that the mosque had repaired on them:

- This mosque was rehabilitated by the Calipha Omar bin Abdul-Aziz, when he was over the emirate of Al-Medina between the years 87 and 93 AH.

- The last renovation of the mosque was during the Ottoman empire and was rebuilt and renewed in the form of a wall that has a height approximately of 2 m as shown in figure 1 which, only preserved the position of the mosque.

Figure1: The Last Rehabilitation phase for Al-Tawbah Mosque

Figure2: The Last Rehabilitation phase for Al-Tawbah Mosque

III. LITERATURE REVIEW

Throughout history, it has been crucial to make efforts to protect cultural monuments and preserve the past. Heritage is often seen as defining societal values and identity in many civilizations. Remains of earlier cultures can provide present societies with a sense of security and belonging and serve as a basis in a world that is continually expanding. Numerous research papers on this field have been published because of its significance.

Mustafaraj, Enea, and Yavuz Yardim (2013), presented a paper in Strengthening and Restoration of Historical Structures-Mirahor Ilyas Beg Mosque in Korça. The Mirahor Ilyas Beg Mosque, built in 1496 in Korça, is one of a few Ottoman mosques still existing in Albania and the only Ottoman monument in the city. The mosque was built using cut stone and brick. It has a strong image; a cubic mass rising over a square plant. Inside there are found pictures of the mosque in the past and different famous mosques. During its existence, it was damaged from many earthquakes occurring at this area. Due to amortization, the mosque's structural properties were weakened, and architectural values were dimmed. Proper strengthening methods need to be applied, not only to improve structural conditions, but also to preserve architectural features of the mosque. In this paper assessment of existing conditions of the structure is carried out. Based on the obtained results, solutions for the structural problems are investigated. As for restoration, the repair methods to be applied were examined taking into consideration at what extent the historical value of the building will be preserved.

Altunışık, et.al (2017), presented a paper In Earthquake Response of Heavily Damaged Historical Masonry Mosques After Restoration. This paper aimed to investigate the restoration effect on the earthquake response of a historical masonry mosque considering the openings on the masonry dome. For this purpose, we used the Hüsrev Pasha Mosque, which is in the Ortakapı district in the old city of Van, Turkey. The region of Van is in an active seismic zone; therefore, earthquake analyses were performed in this study. Firstly, a finite element model of the mosque was constructed considering the restoration drawings and 16 window openings on the dome. Then the model was constructed with eight window openings. Structural analyses were performed under dead load and earthquake load, and the mode superposition method was used in analyses. Maximum displacements, maximum– minimum principal stresses and shear stresses are given with contours diagrams. The results are analyzed according to Turkish Earthquake Code (TEC, 2007) and compared between 8 and 16 window openings cases. The results show that reduction of the window openings affected the structural behavior.

Table1: Materials Properties

	Carrier system components	Material properties		
		Modulus of elasticity (N/m^2)	Poisson ratio (–)	Density ($kg\,m^{-3}$)
Prayer location	Cut stones	1.60×10^9	0.200	2000
	Coarse stone (considering the mortar)	4.50×10^8	0.200	2400
	Brick	1.20×10^9	0.200	2400
Outer part of prayer location	Cut stones	1.60×10^9	0.200	2000
	Marble	3.54×10^{10}	0.316	2690
	Stretcher	2.00×10^{11}	0.300	7850

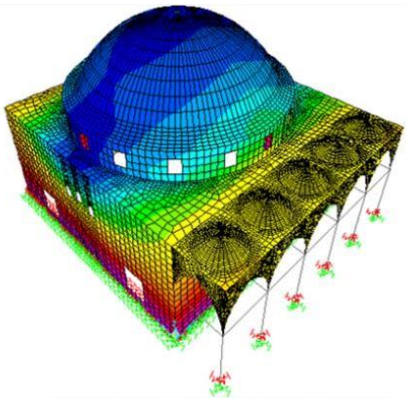
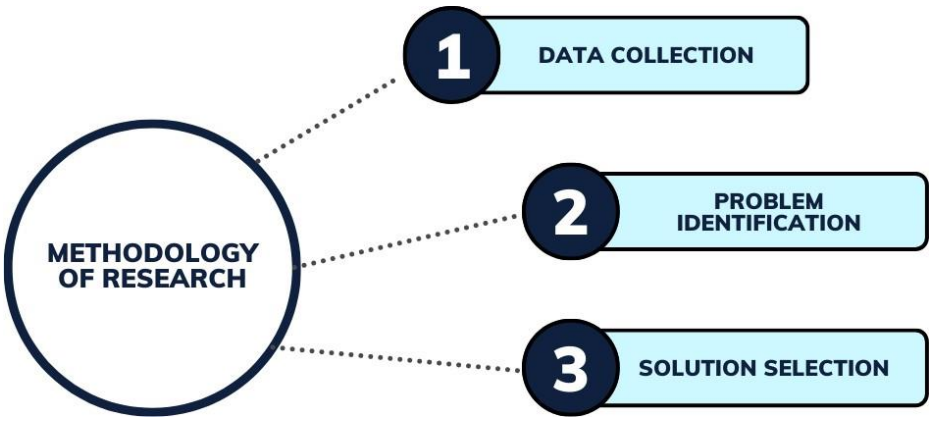


Figure3: Finite Element Model

Altunışık, et.al (2016), presented a paper in a Study on Seismic Behavior of Masonry Mosques After Restoration. In this paper, the seismic earthquake behavior of Kaya Çelebi Mosque, which is in Turkey and the restoration process has continued after 2011 Van earthquake, is determined. Firstly, the dynamic modal analysis and subsequently the seismic spectral analysis are performed using the finite element model of the mosque constructed with restoration drawings in SAP2000 program. Maximum displacements, tensile, compressive and shear stresses are obtained with contours diagrams. Turkish Earthquake Code and its general technical specifications are considered to evaluate the structural responses. After the analysis, it is seen that the displacements and compressive/shear stresses within the code limits. However, tension stresses exceeded the maximum values in some local regions. For this mosque, this is in tolerance limits considering the whole structure. But it can be said that the tension stresses are important for this type of structure, especially between the stone and mortar. So, some additional strengthening solutions considering the originality of historicalstructures may be applicable on maximum tensile regions.

IV. METHODOLOGY OF RESEARCH



V. CONDITION ASSESSMENT OF AL-TAWBAH MOSQUE

Building condition evaluation is the methodical and logical analysis of the structure to pinpoint the issue's origin and location. The many forms of degradation, such as spelling, cracking, staining, etc., provide evidence that the building needs to have its condition assessment. These visible signs of degeneration serve as an indication of the problem. Since there may be more than one reason for a given symptom, there are occasions when symptoms alone are insufficient to determine the best course of action. This will lead to two main types of condition assessment, preliminary investigation, and detailed investigation.

The preliminary investigation contributes to understanding the previous record of the structure as well as assessing the building's apparent physical condition and assessing the building's strength and safety. The preliminary investigation is divided into two main parts which are reviewing the building record and the condition survey. While the detailed investigation is requested in the absence of sufficient data of the studied case, such as the original building drawings and the design of the structure. However, it requires more time and devices. In this report we will focus more on the preliminary investigation.

Figure4: Preliminary investigation for Al-Tawbah Mosque

VI. GEOMETRY OF AL-TAWBAH MOSQUE

During our preliminary investigation of the historical site, we discovered that there were no existing plans indicating the mosque's layout and size. As a result, we determined that an on-site visit was required to physically see the mosque and precisely document its dimensions, as shown in figures (5-6). We correctly measured the mosque's various dimensions using measuring equipment. Following that, we retrieved early site plan drawings, which served as the foundation for producing the final geometry. It is worth noting that the mosque has a virtually square shape and covers an area of around 120 m^2.

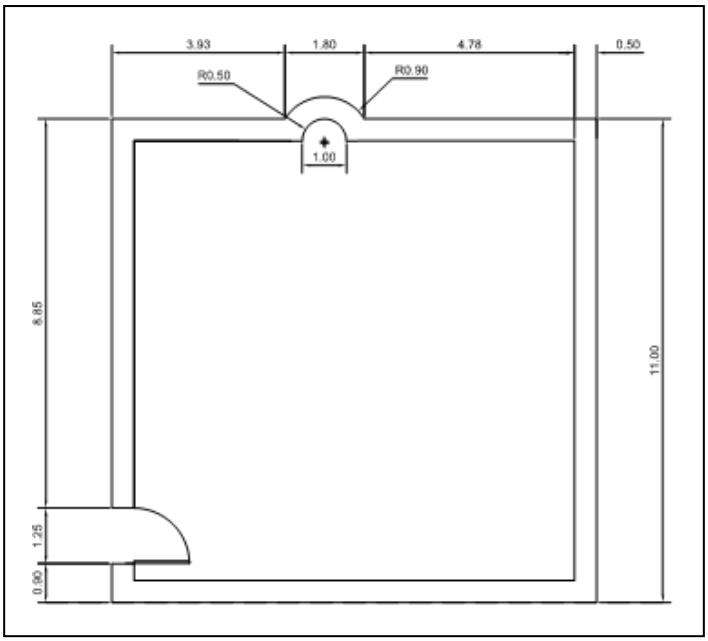


Figure5: The Dimensions of Al-Tawbah Mosque

Figure6: Al-Tawbah Mosque

VII. ASSESSMENT

The initial assessment for the historical site included a detailed visual inspection to determine the mosque's current state. This preliminary evaluation tried to detect any present or possible defects that could jeopardize the structure's safety and stability, as well as the necessity for additional inspection or testing. The examination included a visual inspection and non-destructive testing to evaluate various aspects of the building. The preliminary investigation's findings will be critical in making decisions about the building's future use, as well as in arranging any necessary repairs or alterations. Overall, completing a thorough preliminary investigation is critical for the structure's upkeep and administration because it aids in the prevention of costly and destructive difficulties throughout time. The findings were described in two ways: the first was taken from Gulkan, as shown in Table 2, and the second was the evaluation form approved by the Saudi Commission for Heritage and Antiquities, as shown in Table 3.

Table2: Assessment Deduced from Gulkan	
Date	10/04/2023
Address	Medina – AL-Ashbah Dist
Rough Age of Building (years)	1445
Structural Symmetry	Exists in Plan
Area Covered by building (m^2)	121
No. of Stories	1
Total Height of building (m)	3
Foundation Material	Unknown
Foundation Type	Unknown
Wall Construction	Basalt Stone
Walls are load bearing	Yes
Structural Quality of Walls	Solid Basalt Stone
Typical Wall Thickness (m)	0.5
Lateral Load Resisting Elements	No
Connections	Inadequate
Minarets or other Structural Appendages	No
Mortar / Cementing Material	Unknown
Damage Level: Walls	Severe
Recommendation	Strengthening and Rehabilitation / Further Analysis

Table3: Assessment from Saudi Commission For Heritage And Antiquities		
Building's Name		AL-Tawbah Mosque
Date		10/04/2023
Address		Medina – AL-Ashbah Dist
Ownership		Government Owner
Type of Building		Mosque
Building Age(years)		1445
Main Function of Building		For worship
Historical Significance of Building		Important (Related to the prophet's immigration)
Architectural Design of Building		There is not enough data, but it seems to bea simple design
Building Condition	**Structure Independence**	Independent
	Demolition Rate	collapsed
	Colors and paints	Blackish gray
	Building Additions	None
	Facility Additions	None
	Change in building shape	None
	Incompatible Materials	None
RestorationHistory		It is fully rehabilitated in the period of 87AH
Building Rarity		Distinctive in the Region
Current Building Function		It is a landmark for tourists to learn about Medina's antiquities and pray in the mosque.
Nearness to Important Sites-Tourist attractions sites / sites / Another important sites / Event		Religious locations (The Prophet Mosque) 9.5 km(Quba Mosque) 4.6 km
Integration of building with other tourism and urban sites		Within an integrated system ofurban andtourist sites
Building Damage	**Damages**	Collapsed
	Reasons	Rain Historical Events
	Pollution	Now (no)
	Nature of Use	It is a landmark for tourists to learn about Medina's antiquities and pray in the mosque.
Demolition percentage		95 %

VIII. THE SUGGESTED SOLUTIONS

Several options for the historical mosque can be considered based on the preliminary investigation. These can be summarized as follows:

- **Keeping the mosque as it is**

Keeping the mosque as it is: This strategy comprises retaining the mosque in its current state in order to preserve its historical relevance and authenticity. And the following table presents the advantages and disadvantages of this solution.

Table4: Advantages and disadvantages of the solution

Advantages	Disadvantages
Preserving the mosque in its original form.	Affected when any of the weather changes such asrain and wind.
Lower cost.	Inability to use modern technology.

- **Restoration of the mosque on the old classic character**

Restoration of the mosque to its original historical character: As the mosque has deteriorated or been damaged through time, restoration can be conducted to return it to its original classic character. To achieve historical accuracy, this approach entails thorough restoration work utilizing old materials and procedures. And the following table presents the advantages and disadvantages of this solution.

Table5: Advantages and disadvantages of the solution

Advantages	Disadvantages
Preserving some features of the old mosque.	The inability to expand the mosque due to the failureto use modern means in construction.
Fits with the vicinity of the mosque.	-

- **Rebuilding the mosque on the modern Islamic character**

Rebuilding the mosque in a modern Islamic architectural style: As the mosque has sustained major damage or there is a wish to rejuvenate it with a modern touch, rebuilding the mosque in a modern Islamic architectural style may be explored. This option incorporates modern design aspects while adhering to Islamic architectural standards. And the following table presents the advantages and disadvantages of this solution.

Table6: Advantages and disadvantages of the solution

Advantages	Disadvantages
The ability to use modern technology.	The high cost of rebuilding.

Finally, the decision taken was based on a variety of considerations, including the mosque's structural condition, historical significance, available resources, community preferences, and expert recommendations from architects and preservation specialists and community residents. To decide the best alternative for the preservation and future of the old mosque, a thorough examination and consultation procedure was carried out.

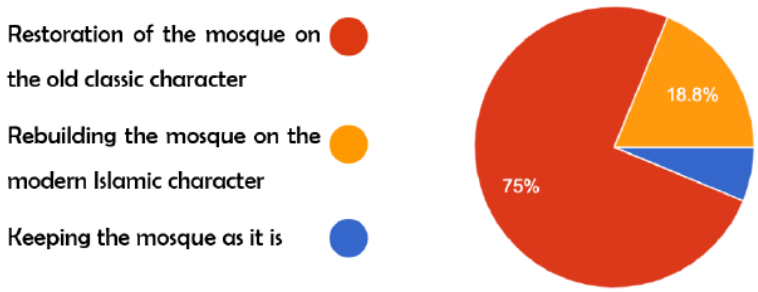


Figure7: The Survey Result

IX. 3D MODEL AND JUSTIFICATION

The repair plan for the historically valuable religious site Al-Tawbah Mosque is described in this justification. Our goal is to retain the building's architectural authenticity while promoting sustainability, cultural remembrance, and community involvement through the use of regional materials like basalt rock and palm wood.

In order to safeguard the continuity of cultural traditions and practices for future generations, it is crucial to preserve this heritage site. The mosque's cultural continuity and authenticity are increased by the renovation project's incorporation of regional materials including basalt rock and palm wood. By include them in the project, we honor regional construction customs and make sure that the renovated mosque accurately represents the region's unique architectural legacy. Local materials can efficiently integrate in with the Al-Tawbah Mosque's original architectural features. They create a harmonious and appealing look by blending in with the surroundings with their colors, textures, and natural beauty. By utilizing these materials, the rehabilitated mosque is made blend in seamlessly with its past context and architectural design, improving the site's overall aesthetic effect. In addition, as shown in Figure 1, the Dome is made of a wooden material that is covered by reinforced glass. This enables the sunlight to enter, so the prayers and visitors can feel the surrounding environment. Also, the plan was modified to be suitable for visitors. The 3D MAX software and RENO software were used to create 3D model and the model was designed regarding to modified AutoCAD plan.

Figure8: Represent the 3D Model of Al-Tawbah Mosque

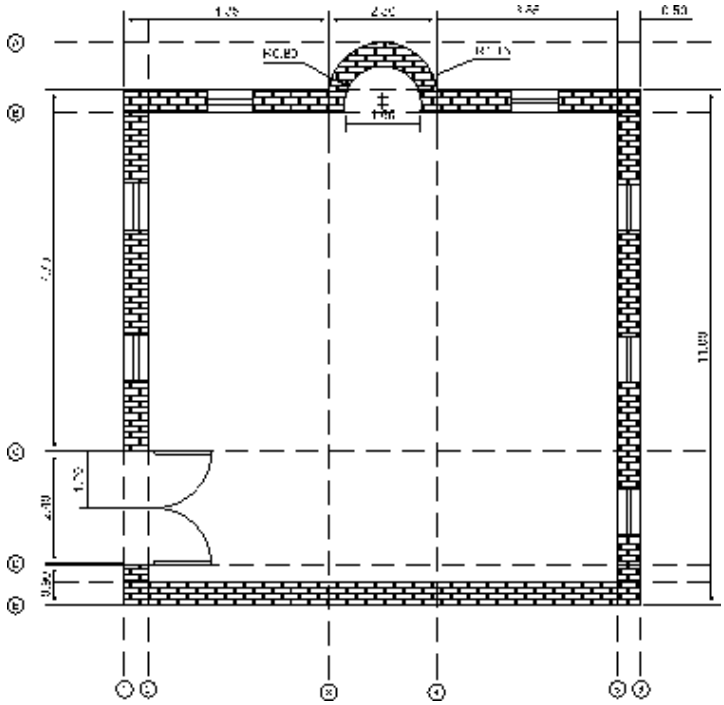


Figure9: Represent the Modified proposed Plan of Al-Tawbah Mosque

X. CONCLUSION

Several major results have emerged from the research of the historical Al-Tawbah Mosque, also known as Al-Nour Mosque, located in the Al-Madinah Al-Munawara district. The mosque is extremely important since it functioned as a place of worship for the immigrants who arrived in Medina and was visited directly by Prophet Muhammad during his migration. The mosque has undergone numerous restoration and repair efforts over the years, with the most recent restorations taking place during the Ottoman empire era.

A physical evaluation was carried out in order to protect the mosque's cultural heritage. Based on the survey results, three potential solutions were presented, with the restoration of the mosque to its original classic character appearing as the most popular option among those polled. In accordance with this technique, a detailed 3D model was produced, combining regionally appropriate elements such as basalt rock and palm wood, assuring the cultural continuity and authenticity of the mosque.

A solid slab system was used throughout the modeling phase in ETABS because of its positive qualities such as cost-effectiveness, time efficiency, and simplified building approaches. The repair plan developed intends to promote sustainability, recognize cultural heritage, and stimulate community involvement, all while preserving the building's architectural uniqueness.

The combination of historical restoration techniques, the use of local materials, and the implementation of a well-planned repair strategy all contribute to the preservation and celebration of the rich architectural and cultural legacy of the Al-Tawbah Mosque.

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