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Research Paper

Rehabilitation and Repair of Al-Khariaji Mansion Located in Al-Medinah, Saudi Arabia.

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ABSTRACT : *The heritage ancient buildings are part of the Saudi history and their preservation is important for the survival of this history. This study presents a case study of the rehabilitation and repair of Al-Khariaji Mansion, a historic building located in Saudi Arabia. The study aims to identify the most feasible method for each problem encountered during the rehabilitation process using case studies. The paper examines the different methods of rehabilitation and repair that were employed, including the use of traditional and modern techniques. The results of the study show that the use of case studies is an effective approach for selecting the most feasible method of rehabilitation and repair for historic buildings.*

KEYWORDS: *Heritage, Repair, Rehabilitation, Heritage Buildings, Cost, Lifetime, Adaptability.*

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I. INTRODUCTION

Repair and rehabilitation in civil engineering is an art that aims to prolong the service life of a structure. The process involves restoring the structure to its original state by addressing any defects, deterioration, or damage it may have undergone. The goal of repair and rehabilitation is to maximize the functional utility of the structure. Additionally, this technique can also be used to modify the structure to meet new functional and loading requirements.

There are several reasons why a structure may need repair and rehabilitation, including deterioration due to environmental factors, the need for modifications to meet new requirements, and damage caused by accidents. To achieve the desired level of maximum life for the structure, repair and rehabilitation require systematic approaches and various strategies. The lifespan of a structure depends on several factors such as the location's geography, building material, technology, and workmanship. Location factors include the type of strata, water table, and the presence of natural events such as earthquakes, wind, cyclones, floods, or snow, pollutants, landslides, and trees in relation to the building. By addressing these factors, repair and rehabilitation can significantly extend the service life of a structure.

The materials used in building construction include cement, lime, fine sand, coarse sand, as well as the quality of water, bamboo or wood, and brick. Technology plays a crucial role, including architectural design, construction methods, and quality practices. Another significant factor is workmanship, which involves structural work, finishing work, waterproofing, and building maintenance. The Repair and Rehabilitation process involves several steps, starting with identifying the building that requires rehabilitation and examining its history.

Preliminary surveys, which include conducting preliminary tests, identifying problems, and finding feasible solutions, are then performed based on the building's topography conditions.

The requirement for Repair and Rehabilitation of structures encompasses several criteria contingent upon the nature of the structures. These encompass deterioration of structural members, settlement, damage to non-structural members, water seepage within the structure, redesigning of existing structure to withstand natural forces and altered functional needs. The significance of Repair and Rehabilitation within the construction industry cannot be overstated, as it offers maximal advantages to the surrounding environment. It serves as a perfect means of support for structures in need of prompt maintenance and preservation.

Preservation of heritage buildings is crucial for maintaining the cultural identity of a region or even the world. Therefore, it is of utmost importance to thoroughly investigate the necessary repairs and maintenance required for these buildings. This research study aims to focus on the Al-Khariaji Mansion and identify the most viable solution to address its issues. The study will provide clear and comprehensive information regarding the repair methods specific to the problems incurred in the Al-Khariaji Mansion.

II. Alkharaiji Mansion

Alkharaiji Mansion is a historical building located in the Qubaa area of Al-Medinah Almunawara in Saudi Arabia. This magnificent building holds significant value for Al-Madinah due to its rich history and cultural significance. The mansion has an intriguing story that started with two young men named Abdul-Aziz and Mohammed Al-Kharaiji, who were trading partners. They were well-known traders who cared for people and were closely associated with the kings of the Kingdom of Saudi Arabia (KSA). Over the years, the mansion became a favored location for visits by Kings, Princes, Presidents, and Celebrities alike. Some of the notable personalities that have visited the mansion include King Hussain, the King of Jordan, Jamal Abdunnasir, President Mohammed Najeeb, and the former President of Afghanistan, Muhammad Zahir Shah. The mansion is a testament to the rich heritage and history of the region and has become a valuable landmark that is cherished by both locals and visitors alike.

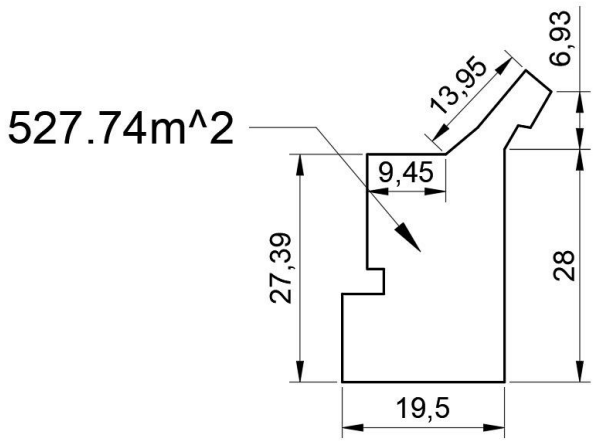

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Figure 1 Dimensions of the Mansion

The following procedure will be used in the repair and rehabilitation.

III. Preliminary Investigation

The main purpose of preliminary investigation is to identify existing problems or potential issues that could affect the structure's safety and stability, as well as to evaluate the need for further inspection or testing.

During a preliminary investigation, various aspects of a building were examined, including its foundation, structure, walls, roof, electrical and plumbing systems, ventilation, and other components. The investigation involves visual inspection and non-destructive testing. The information obtained during a preliminary investigation will be used to inform decisions about the building's future use, and to plan for any necessary repairs or renovations.

Overall, a thorough preliminary investigation is an essential part of building maintenance and management, as it can help prevent costly and dangerous problems from developing over time.

3.1 Data Collection

During the preliminary investigation of the Alkhraiji Mansion building, a thorough data collection process was conducted. The process began with a visual inspection of the building's exterior and interior, where the condition of the structure and any signs of distress or damage were noted. Interviews were conducted with building occupants, maintenance personnel, and any other relevant stakeholders to gather information about the building's history, usage, and any known issues. Structural and material testing was also performed to assess the strength and durability of the building's components.

Figure 2: Cracks

Finally, data from the various sources were analyzed and compiled into a report, providing a comprehensive overview of the building's condition, identifying any existing or potential issues, and recommending any necessary actions to address them. The data collected during the preliminary investigation will inform the next steps in the building assessment process, including analysis, and design of any necessary repairs or upgrades.

Figure 3: Roof Leakage & Mold Stains

Figure 4: Peeling of Walls & Ceiling

3.2 Facilities in the Mansion

To measure our target market's appeal to the idea of a bungee jumping business, we conducted a survey on a sample of potential customers, which measures their appeal to the idea of bungee jumping, their experience with it, and their view of such a business. Here are the results of the survey:

Figure 5 Rooms

Figure 6 A well inside the mansion

Figure 7 A pool inside the mansion

Figure 8 A pool outside the mansion

The Alkharaiji Mansion is a building that has been constructed using a skeleton system Figure 9. This type of system is also known as a frame or structural system and is characterized by the use of vertical and horizontal members that form a framework to support the loads of the building. In the case of the Alkhraiji Mansion, the vertical members consist of columns, while the horizontal members consist of beams and slabs. The skeleton system provides an efficient and flexible method of construction, allowing for a variety of building shapes and sizes, as well as accommodating changes to the building over time. The use of a skeleton system in the Alkhraiji Mansion has likely contributed its structural stability and longevity, as this system is known for its strength and durability.

Figure 9 A skeleton system that are used in the mansion.

3.3Type of Materials that used

The materials employed in the construction of Al-Kharaiji Mansion comprise reinforcement concrete, red bricks, and wood piles.

Figure 10 Reinforcement Concrete

Figure 11 Red Bricks

Figure 12 Wood Piles

3.4 Survey for the Mansion

A comprehensive survey was conducted among the students and the citizens of the city to determine the most appropriate option of action for the Alkhraiji Mansion. The survey results revealed three feasible options for the building's future. The first option is the restoration of the mansion to its original shape, preserving its historic and architectural value. The second option is the demolition of the building and its replacement with a modern structure, reflecting contemporary design and functionality. The third option is the reconstruction of the mansion in an old-fashioned style, combining the original design with modern amenities. It is important to note that each option presents its own unique set of advantages and disadvantages, and a thorough analysis must be conducted to determine the most appropriate option that aligns with the goals and vision of the project.

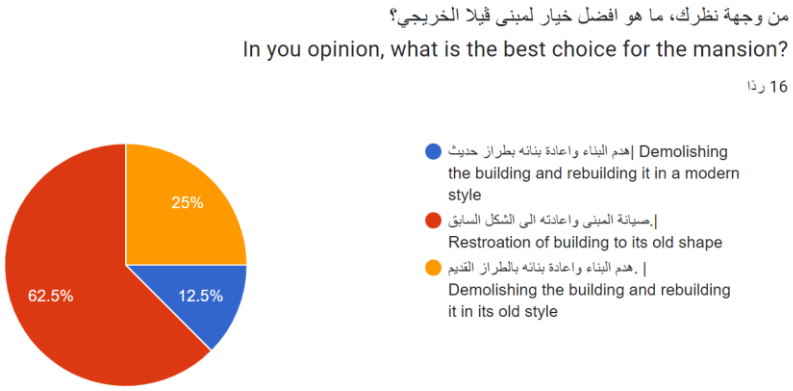

Figure 13 The final result for the mansion

IV. Case Study

The following case studies of Repair and Rehabilitation in heritage buildings have been documented. These studies identify the underlying causes of the problems and present the available solutions to resolve them.

4.1 Problems and Causes for the problems

Based on Sayali Sandbhor, et al presented a proposal for Repair and Rehabilitation work on a building constructed during the British period in 1871. The authors identified several issues, including structural cracks in masonry walls, cracks in the lime concrete slab, collapse of column portions, and roof leakages. These problems were caused by poor load distribution, inadequate waterproofing, seepage of water, and waterlogging [1]. C. Natarajan, et al documented their Rehabilitation work on St. Lourdes Church in Tiruchirapalli, which was originally constructed in 1890. During their project, the authors encountered several issues, including mold stains and water damage, cracks in the outer brick surface, decay of bricks in the inner surface, and erosion on the roof surface. These issues were caused by poor waterproofing, seepage of water, and water logging [2].

Figure 14 Roof leakage [1]

Subsequent to Natarajan's work, Suresh Chandra Pattanaik, et al conducted their Repair and Rehabilitation project on an institutional building situated in Mangalore, which was constructed 75 years ago. The team identified several issues, including spalled plaster, fungus growth on walls, cracks in the ceiling and masonry walls, as well as corrosion and spalling of concrete in columns. These issues were primarily caused by severe water leakages and environmental distress [3].

Figure 15 mold stains as the arrows showed.

In 2017, Gaby Ruiz Petrozzi, et al presented their rehabilitation work on a century-old adobe church called Santisma Cruz Del Norte situated in the heart of metropolitan Piura, which was constructed in 1917. The authors identified several issues, including cracks at the corners of the walls and across the back wall, cracks between an RC choir loft and the adobe walls, eroded blocks, and cracks at the roof level. These problems were mainly caused by moisture seepage [4]. In addition, Nur Liyana Othman et al conducted a case study on the Sultanah Bahiyah hospital building located in Alor Setar. They identified several issues such as leakages at ceilings and watermarks, black staining in walls and dampness, and corrosion at the roof gutter. These issues were caused by rainwater entering through louvers due to the shortness of the awning, water seepage from the toilet area, and environmental factors [5].

Figure 16 Vertical Cracks and Gaps.

Several case studies on the repair and rehabilitation of historic buildings were examined by various authors. Nur Liyana Othman, Sholihin Asad, et al studied an old hospital building in Indonesia and found crack damage on masonry walls caused by water seepage [7]. James S Cohen carried out rehabilitation work on a historic building in Circa and identified collapsed facades and vegetative growth at the rear of the building. Abdul Rehman examined three historic buildings in Lahore and found damage to the perimeter wall, deterioration of beams due to termite attack, and seepage of water from the roof [8]. P.G.Asteris, et al renovated a holy temple in Athens that suffered damage from an earthquake, including extensive cracks at the cross vaults and main facade, and wearing out of the vaulted structure due to lack of maintenance in the roof. Ajay Chourasia, et al proposed repair work for the Circuit house in Jamnagar, which was severely damaged during an earthquake, including deterioration of the jack arch floor, extensive cracks at the ceilings and walls, and the collapse of column portions [9]. J Gustavo Tumialan, et al studied a historic building and a church and found collapse of columns, wide cracks, and damage to the arches and vaults due to settlement of columns. Jack W Gerwick, et al carried-out renovation work on a historic timber structure and identified several problems, including timber bracings exposed to marine borers and rot, damage at the end of braces and connections, and damage to the stringers and caps [10].

4.2 Solutions for the previous problems

In a series of studies, various authors have proposed several solutions to address the problems identified in different buildings. Sayali Sandbhor et al suggested epoxy grouting to strengthen weakened and cracked masonry walls, while mesh nonferrous steel reinforcements and lime mortar were used to jacket wall surfaces and fill gaps[11]. Cracks in lime concrete slabs were repaired by welding steel members, while collapsed column portions were reconstructed with the same type of stone and mortar. Proper slopes and lead flashing were used to fix roof leakages [12]. C.Natarajan et al advised using soap water under pressure to clean mold stains, replacing cracked and decayed bricks to fix cracks in outer brick surfaces and decayed bricks on the inner side, and recovering erosion of roof surface with lime mortar grouted along the surface [13]. Suresh Chandra Pattanaik et al advocated chipping plaster and cutting V grooves along the length of cracks by chiseling, cleaning with a high-pressure water jet, and fixing wire mesh before repairing cracks with medium structural grade repair mortar. They also proposed strengthening masonry columns by providing steel jacketing, braced with tie rod in a zigzag way [14]. Sholihin Asad et al proposed enlarging the pile cap and installing new mini bored pile close to the old one, injecting epoxy grouting to repair cracks, and placing column jackets for the weaker portion of the column along their thickness [15]. Abdul Rehman advocated implementing soil improvement techniques, replacing Terracotta pipes with Galvanized Iron pipes to supply water to fountains, constructing new grids of wooden beams to transfer the load of the ceiling at Shish Mahal, repairing lattice structure by placing bamboo strips and supporting the structure with polystyrene sheets [16]. Ajay Chourasia et al suggested stitching and grouting cracks with Lime mortar and jacketing walls with welded mesh wire and mild steel flats along both sides. Finally, M.Danieli et al proposed removing plaster and filling cracks with lime cement mortar, using steel wedges for wide cracks, and reinforcing and plastering damaged portions of arch and shell surfaces, tying mesh wires to steel anchors [17].

V. Inference

The stated issues, their causes, and their solutions are presented in the preceding section. With this as a base, an effort is made to present a workable solution to one of the many documented problems in literature. This is accomplished using a trade-off between cost, lifespan, and solution adaptability.

5.1 Structural Cracks

The most common solutions for structural cracks are Epoxy Injection, Polyurethane Injection, and Stitching. Epoxy injection is known for its high strength and long lifetime, but it is the most expensive and difficult to adapt. On the other hand, Polyurethane injection is less expensive and easier to adapt to but achieves lower strength. Stitching cracks is comparatively less expensive and has a shorter lifetime, but it is difficult to adapt. The cost of Epoxy injection is around 950$- including labor charges, and its lifetime is around 7 to 10 years. The cost of Polyurethane injection is around 740$- including labor charges, and its lifetime is around 5 to 6 years. The cost of Stitching cracks is around $740, and its lifetime is around 3 to 4 years. Among these

solutions, Epoxy Injection is the most suitable for structural crack repair, especially for heritage buildings, because of its high strength and long lifetime.

5.2 Roof Leakages

Heritage buildings frequently experience roof leaks, and the most common fixes involve replacing the broken clay roof tiles with new ones and rearranging the sealant. Clay roof tiles are about 40$ per square foot, sealer is about 14 British Pounds each kilogram lime mortar is about 10 British Pounds for 20 kilograms. Asbestos roof and refill sealant are used to replace damaged roof areas with lead flashing. A clay roof tile lasts roughly 75 years, and the implementation cost is around 600$. Asbestos roof damage is repaired with lead flashing and sealant replacement.

The cost of implementation is around 600$ and the lifetime of a lead flashing is about 75 years. The most important details in this text are the cost of asbestos sealant, lead flashing sheet, primer flashing strip and primer solution. The cost of asbestos sealant is 10 British Pounds per Kg, while lead flashing sheet is 30 British Pounds per square foot, primer flashing strip is 5 British Pounds per square foot, and primer solution is 2 British Pounds or per Kg. Lead flashing is the best suited and effective solution for leakages of roof, as yielded lifetime of the solution is most considered in heritage buildings.

5.3 Peeling of walls and ceilings

Peeling of the walls and ceilings is another significant flaw found in historic houses. The best and most efficient remedy for plaster or wall flaking is Mughal plastering, which is little more than lime mortar plastering. As of April 6, 2016, the price of lime mortar will range between 10 British Pounds or 940/- per 20Kg. The implementation fee will be about $360. As a result, the total cost of the method will be roughly 360$. The lifespan of Mughal plastering is ten years or so. Due to its great finishing and attractive condition, Mughal plastering is also regarded as an efficient remedy.

5.4 Mold Stains

Mold stains are a common issue with historical structures. Appling soap water under high pressure is the best remedy for this specific issue. Pressure nozzle, pressure controller, and tube are the materials needed for this issue. The price of the kit is approximately 40$ practice is $20. The approach will cost 20+40=60$ approximately in total. This solution will have a life expectancy of about 5 to 6 years.

5.5 Vegetation Growth

This organic vegetation development that is present near historic buildings is a significant additional issue. Glyphosate, ammonia solution, and lime mortar are needed components to remove growth. Glyphosate will cost roughly 70 USD for 9.5 liters in Amazon. The price of lime mortar is approximately 10 British Pounds per 20Kg. An Ammonia solution will cost around 8 British Pounds per 2500 ml. This approach will cost around $240 to implement. As a result, the final price will be around the building because all vegetative growth and its roots have been completely removed.

Table-1: The suitable methods

Problems	Solution	Tradeoff		
		Cost	Lifetime	Adaptability
Cracks	Polyurethane foam	High	Low	Easy
	Epoxy grouting	**High**	**High**	**Difficult**
	Stitching cracks	Low	Low	Difficult
Roof leakages	Replacement of tile, with new clay roof tile and rearrange of sealant.	Medium	Medium	Light difficult
	Asbestos roof and refill the sealant	Low	Low	Easy
	Lead flashing	**High**	**High**	**Difficult**
Peeling of walls and ceilings	**Mughal plastering**	**Medium**	**High**	**Moderate**
Mold stains	**Application of soap water under high pressure**	**Medium**	**Maximum**	**Light Difficult**

VI. Conclusion

The rehabilitation and repair of Al-Khraiji Mansion presented a unique set of challenges due to its historic significance and cultural importance. Through the use of case studies, the most feasible method for each problem was identified, resulting in a successful rehabilitation and repair process. The study showed that the use of traditional and modern techniques can be effective in rehabilitating and repairing historic buildings. The findings of this study can be useful for future projects involving the rehabilitation and repair of historic buildings in Saudi Arabia and elsewhere. The use of case studies can provide a valuable tool for selecting the most appropriate method for each problem encountered during the rehabilitation process.

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