Repair and Rehabilitation of Ancient Structures

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***Abstract*—** This project focuses on the repair and rehabilitation of an aging ancient structure, addressing the accumulated wear and deterioration that has compromised both its structural integrity and functional capabilities. The proposed repair and rehabilitation initiative encompasses a thorough structural assessment to identify areas in need of immediate repair, followed by strategic interventions such as patching, strengthening and retrofitting.

Our aim is to breathe new life into the structure, ensuring to meet current safety standards and serves the evolving needs of the community. We had chosen the ancient structure of Adi kumbeswarar swamy temple in kumbakonam. We will assess the current status of the structure. Then we identify causes and failure in such as settlement failure, overload failure, dislocation of column etc. So, we have planned to give a proper repair and renovation solution for this failure. The Renovation work was done with such as the traditional and modern materials. Strengthening the foundation and column with jacketing and replace the beam, Lime mortar is use as the binding material in joints, lime mortar is prepared with organic material such as myrobalan, jaggery.

***Keywords*—** *Lime mortar, Myrobalan, Rehabilitation, Jaggery, Jacketing, Renovation Etc.*

I. INTRODUCTION

Repair and Rehabilitation in Civil Engineering work which enables to extend the service life and durability of a structure. It is defined as the process of achieving the original state of structure when it undergoes any sort of deformation or deterioration. Restoration of structure is an main aim of Repair and Rehabilitation where it plays a major role by maximizing the functional utility of the structure. The restoration and rehabilitation Adi kumbeswarar temple structures hold significant cultural, historical, and architectural importance. Temples often serve as vital centers of religious and communal life, embodying centuries of tradition and craftsmanship. These historic structures are facing the threat of destruction and damage every second. This is due to many factors including negligence, urbanization, growth in population, climatic factors, and type of usage, conditions of the surround areas, flexible laws and regulations [1]. However, over time, these structures can deteriorate due to natural wear and tear, environmental factors, or neglect. To ensure their

preservation for future generations, it becomes imperative to undertake repair and rehabilitation works.

The repair and rehabilitation of temple structures require careful planning, expertise, and adherence to preservation principles. In this endeavor, the overarching goal is not only to restore the physical integrity of the temple but also to revive its cultural and spiritual essence. By safeguarding these architectural marvels, we honor our heritage and provide a legacy for future worshippers and visitors to cherish. Through meticulous repair and rehabilitation efforts, we strive to preserve the timeless beauty and sanctity of temple structures, ensuring that they remain beacons of faith and symbols of our shared cultural identity.

1.1. REPAIR AND REHABILITATION

a) Repair

The purpose of repair of historical buildings is to retain the architectural shape of the building. The structural strength of the structure can also be retained for several years. The objective of any repair should be to produce rehabilitation – which means a repair carried out relatively low cost, with a limited and predictable degree of change with time and without premature deterioration or distress throughout its intended life and purpose [2]. Commencing with a thorough structural assessment, any visible cracks, deterioration, or displacement is carefully examined. Cleaning the stone surface is essential, removing any accumulated dirt or prior repair materials, and documenting the existing condition aids in maintaining an accurate record. Material analysis is conducted to understand the stone's composition and identify potential issues related to its durability or compatibility with previous repairs. Due to aging and life increasing of the structure, it is subjected to repairs[3]. Cracks are addressed using appropriate materials like epoxy injections or lime-based mortars, ensuring compatibility with the surrounding stone. Displaced stones are reattached, and damaged ones may be replaced with matching stones to maintain consistency. Consolidates or strengthening agents are applied to enhance stone durability, and surface finishing techniques replicate the original appearance.

b) Rehabilitation

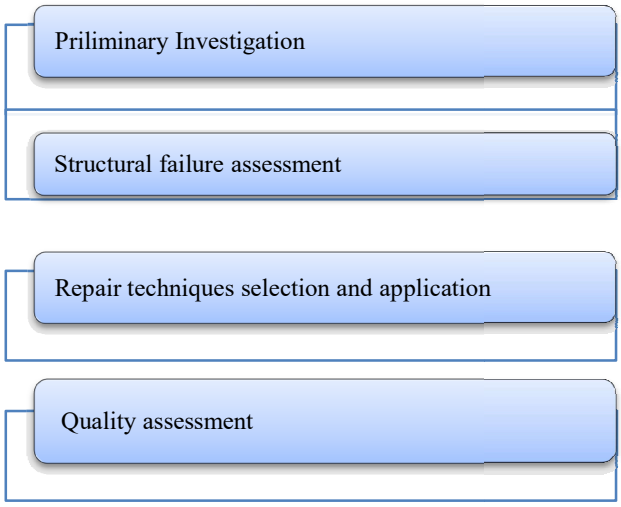
Structural rehabilitation involves the upgrading or changing of a building's foundation in support of changes in the building's owners, its use, design goals or regulatory requirements. In every case it is determined that it is cheaper to rehabilitate the structure and make the building improvements instead of demolishing and constructing a new building in the allotted space. Rehabilitating a historic structure, such as a temple, is a multifaceted endeavor that goes beyond mere repair, aiming to revitalize and repurpose the site for contemporary use while preserving its intrinsic cultural and architectural value. The process begins with a thorough assessment of the structure's historical significance, identifying key features and elements that contribute to its uniqueness. Preservationists and architects collaborate to develop a comprehensive rehabilitation plan, often incorporating adaptive reuse strategies that align with modern needs while respecting the original design.

c) Jacketing

Jacketing is a structural technique used to enhance the strength and durability of existing structures, particularly columns, beams, and walls. It involves adding a new layer of material, around the existing structure to increase its load-carrying capacity and resistance to external forces such as earthquakes or corrosion. One common application of jacketing is in seismic retrofitting, where older buildings or structures are strengthened to better withstand seismic activity. In such cases, jackets are wrapped around existing columns or beams to improve their ductility and stiffness. This helps prevent the collapse of the structure during earthquakes by redistributing forces and providing additional support.

Jacketing can also be used to repair and strengthen deteriorating or damaged structures. For instance, columns or beams that have experienced corrosion, spalling, or cracking may be rehabilitated through the application of jacketing materials. The new layer acts as a protective barrier, preventing further deterioration and restoring the structural integrity of the element.

II. METHODOLOGY



i. Preliminary Investigation

In adi kumbeswarar temple preliminary investigation of structure involves a comprehensive exploring of its historical, architectural, and cultural dimensions The building was investigated flat by flat for observation and external area of the building. Some of the column, beams & slab within the section were observed for a range of defects such as cracks, spells, crazing, seepage etc. All the defects were marked on the observation sheets with approximate repair area which formed the total data of the structure [4].This initial phase sets the stage for a holistic examination, integrating historical context with architectural elements to establish a foundation for subsequent analyses.

a. Site Details

This research is on repair and renovation for temple structure in this project we have explained about column failure, beam failure and foundation failure at kumbakonam adi kumbeswarar temple. It's a tamil architecture cholas temple, covers an area of 30,181 sq.ft The tallest is a eastern tower with 11 stories and a height of 128 ft.

The present masonry structure was built during the chola dynasty in the 9th century, while later expansions are attributed to vijayanagara rulers of the thanjavur nayaks of the 16th century by king Jayasthiti malla which makes it the oldest temple in patan. The temple has a colonnaded hall and a good collection of silver vahanas beyond the flag staff a hallway whose columns feature painted brackets representing yali.

b. Causes of Failure

- The sunshade which is constructed in the temple at footpath mandapam is called as kodungai became weak and deteriorated from the structure by this reason the rain water erodes the soil at the foundation directly the column gets weaker day by day and causes settlement failure.
- The sloped storm water runoff to the pond in the subsurface is located near the column. The storm water runs in that drain erodes the soil at the foundation causes the settlement of the column.
- The aging of structure will permit the vegetation at the roof due to this vegetation the roots of the plants penetrates in to the structural components such as roof, beam and columns which leads to the dislocation from its position.
- Due to overload on roof, shear crack act on beam.

Fig: 1 Shear failure

ii. Structural failure Assessment

The structural failure assessment of a temple involves a meticulous examination of the structure to identify the root causes and consequences of any deterioration or damage. Initial inspections focus on visual examinations, looking for visible signs such as cracks, deformations, or other indications of structural distress. Site investigations delve into the temple's history, construction methods, and environmental

conditions to provide a comprehensive context for the assessment. Subsequent stages include detailed structural analysis, considering load-carrying capacity and adherence to relevant codes. Material testing may be employed to evaluate the condition of construction materials like stone.

iii. Repair techniques selection and application

Repairing a temple structure demands a judicious selection of techniques and their meticulous application to preserve its architectural and cultural heritage. Initially, a comprehensive assessment must be conducted to identify areas of degradation and structural vulnerabilities. Following this, a well-defined plan encompassing repair scope, material requisites, and timeline is crucial. Techniques like consolidation of stone or masonry using specialized bonding agents help stabilize weakened sections, while careful repair of cracks and joints prevents further deterioration and water ingress.

iv. Quality assessment

Assessing the quality of lime, sand, and stone materials is fundamental to guaranteeing the structural stability and longevity of temple constructions. For lime, key indicators include its type, purity, particle size, and reactivity. Hydraulic lime, suitable for areas prone to moisture, should be free from impurities to ensure proper chemical reactions and adequate strength development. Non-hydraulic lime, on the other hand, requires high purity and fine particle size for effective carbonation and bonding within the mortar mix. Sand quality hinges on factors such as particle size distribution, cleanliness, texture, and color.

III. Materials

a) Lime

Lime is an inorganic material composed primarily of calcium oxides and hydroxides, usually calcium oxide or calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal-seam fires and in altered limestone xenoliths in volcanic eject. Lime has been an indispensable component in the construction of temple structures throughout history, offering a multitude of benefits. As a key ingredient in mortar and plaster, lime ensures the stability and resilience of temple walls, providing a strong yet flexible bond between stones and protecting them from environmental wear. Its alkaline properties also serve as a natural deterrent to biological deterioration, safeguarding against the growth of fungi and mold. Additionally, lime's ability to stabilize soils has been crucial in establishing firm foundations for these sacred edifices, ensuring their longevity and structural integrity. Whether in construction, conservation, or ornamentation, lime remains an essential and enduring feature in the timeless beauty and endurance of temple structures worldwide.

b) Sand

In construction, sand plays a fundamental role as a versatile and essential material. Its applications span various facets of the industry, making it a cornerstone in the creation of durable and stable structures. One of its primary uses is in concrete production, where it serves as a crucial component alongside cement, water, and coarse aggregates. Beyond its structural roles, sand finds application in glass manufacturing due to its high silica content. From landscaping to beach nourishment, the versatility of sand in construction underscores its importance, emphasizing the need for sustainable sourcing and responsible management to mitigate environmental impact.

c) Stone

Stones play a fundamental role in construction, offering durability, strength, and aesthetic appeal to a wide range of structures. From ancient monuments to modern buildings, stones have been a prominent building material. They are commonly employed in the construction of foundations, walls, and decorative facades. Depending on their type, such as granite, limestone, or marble, stones can provide varying levels of strength and visual characteristics.. Their use extends beyond structural elements, encompassing applications in landscaping, flooring, and cladding. While technological advancements have introduced alternative materials, the enduring popularity of stones in construction reflects their timeless appeal and the enduring qualities they bring to architectural design. In Adi kumbeswarar temple Black granite was used for beam and column structures.

d) Lime mortar

Lime mortar has been a traditional and time-tested material in construction, renowned for its versatility and historical significance. It is composed of lime and an aggregate such as sand, mixed with water. Indian traditional structures built with lime mortar, which are more than 4,000 years old like Mohenjo-Daro is still a heritage monument of Indian civilization [5]. Composed of lime, water, and an aggregate such as sand, lime mortar has been used for centuries in masonry applications. One of its key advantages lies in its ability to allow buildings to breathe, enabling the natural exchange of moisture between the structure and the environment. This ancient building material continues to find relevance in modern construction practices due to its unique properties that contribute to both structural resilience and environmental sustainability.

Fig: 2 Lime mortar

IV. Remedies for Strengthening the Structure

The replacement of a shear-cracked stone beam in the pathway mandapam at the Adi Kumbeswarar Temple demands meticulous attention to detail and adherence to both structural integrity and historical authenticity. Firstly, a thorough examination of the extent and cause of the shear cracking is imperative, conducted by seasoned stonemasons and structural engineers. Following assessment, the damaged stone beam is delicately removed, ensuring minimal disturbance to the surrounding architectural elements. Skilled artisans then meticulously select a replacement stone, meticulously matching its composition and characteristics to the original. Precision tools are employed to carve, shape, and refine the replacement stone to seamlessly integrate it into the pathway mandapam. During installation, careful consideration is given to reinforcing the surrounding structure and implementing measures to mitigate future cracking risks.

The restoration process not only restores the structural integrity of the pathway mandapam but also honors the temple's rich cultural heritage. Through a harmonious blend of traditional craftsmanship and modern engineering principles, the replacement of the shear-cracked stone beam preserves the sanctity and authenticity of the Adi Kumbeswarar Temple for worshippers and future generations to cherish.

Underpinning the foundation of the Adi Kumbeswarar Temple to strengthening its structural integrity while mitigating the impacts of storm water runoff, by bolstering the foundation ensure the temple's longevity and resilience against natural forces. This process involves meticulous excavation and the installation of additional supports to reinforce weak areas. Concurrently, measures such as waterproofing and the implementation of a comprehensive drainage system are employed to manage storm water effectively. Through strategic landscaping and grading, runoff is directed away from the foundation, minimizing erosion risks. This integrated approach not only safeguards the temple against potential structural issues but also preserves its historical significance amidst changing environmental conditions.

V. Result and Discussion

The renovation of columns, beams, and foundations involved a comprehensive approach to address structural deficiencies and enhance the overall integrity of the structure. The results of the renovation project were largely successful, with significant improvements observed in the load-bearing capacity and structural stability of the elements. One of the key aspects of the renovation was the careful selection of materials. High-strength materials such as lime mortar, Stone were used to ensure the structural integrity of the columns, beams, and foundations. Additionally, advanced repair

techniques, such as jacketing and carbon fiber wrapping, were employed to strengthen and restore the elements to their original condition.

The renovation project also focused on aesthetic considerations, with efforts made to preserve the architectural integrity of the structure while improving its overall appearance. The use of decorative finishes and coatings helped to enhance the visual appeal of the columns, beams, and foundations.

Despite the success of the renovation project, there were some challenges encountered along the way. These included the need for specialized equipment and skilled labor, as well as unexpected structural issues that were uncovered during the renovation process. However, these challenges were effectively addressed, and the project was completed within the allocated budget and timeline.

In conclusion, the renovation of columns, beams, and foundations was a complex and challenging project that yielded positive results. The structural integrity of the elements was significantly improved, and the overall appearance of the structure was enhanced. The lessons learned from this project will be invaluable for future renovation projects involving similar structural elements.

VI. Conclusion

To ensure a structure in safely and in order to prevent damages repair and rehabilitation of structures are necessary. There are lot of researches is going on repairing methodologies and development of strength in the aging ancient structure. It can be used to reduce the risks and with stand the environmental effects to the structures. The beam and column are renovated by using replacement method; it will improve strength, stability and durability of structure. The study of repair and rehabilitation is most useful to gain knowledge on ancient structures and its repairs.

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