



"Change of Address: Transforming Landscapes Through Structure Relocation in Maharashtra"

Balancing Heritage and Innovation in the Intricate Art of Structural Relocation

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Abstract: The relocation of structures is a complex and intricate endeavour that entails moving buildings, bridges, and other architectural marvels from one location to another. This process requires a harmonious blend of engineering expertise, historical preservation, and meticulous planning. Structures are uprooted, transported, and meticulously repositioned, often crossing considerable distances. Whether it's a historic mansion, a colossal bridge, or a lighthouse, each relocation project presents its unique set of challenges. Engineering teams use cutting-edge technology and employ a combination of hydraulic jacks, self-propelled modular transporters, and other innovative tools to achieve the seemingly impossible. The intricate planning and execution behind structure relocation represent a testament to human ingenuity, preserving architectural treasures and redefining the boundaries of what can be moved.

Index Terms - Heritage Preservation, Engineering Challenges, Historic Architecture, Site Transfer, Building Transport

I. INTRODUCTION

Structure relocation, often considered an engineering marvel, is the intricate process of moving buildings, bridges, and other architectural wonders from one location to another. This remarkable feat involves a combination of engineering expertise, careful planning, and a deep appreciation for history and preservation. Whether it's a historic mansion facing demolition, a historic bridge obstructing urban development, or a lighthouse threatened by coastal erosion, structure relocation offers a lifeline to these treasures. This introductory exploration delves into the art and science behind structure relocation, shedding light on the challenges, innovation, and significance of preserving our architectural heritage through these incredible endeavours.

Structure Relocation

Structure relocation is a complex process that involves moving buildings, bridges, or other large structures from one location to another. It demands careful planning, engineering expertise, and cutting-edge technology to ensure the safe and precise transfer of these structures. Whether for historical preservation or urban development, structure relocation represents a remarkable feat of human ingenuity and engineering prowess.

II. PROBLEM STATEMENT

The relocation of structures, whether for historical preservation or urban development, presents a multifaceted problem. Preservationists seek to safeguard architectural heritage, while developers aim to repurpose or reposition structures to meet contemporary needs. Balancing these conflicting interests is a complex challenge.

The intricacies of structure relocation extend beyond architectural considerations. Engineering hurdles are abundant, ranging from the structural integrity of the building during transport to the complexities of site preparation and ensuring public safety. Route selection, permitting, and compliance with legal and environmental regulations add layers of complexity to these projects. Financial constraints and securing funding for often expensive relocation efforts are substantial problems. Furthermore, engaging with local communities and stakeholders is essential, as the relocation of a structure can significantly impact the neighbourhoods in which it occurs.

In essence, the problem of structure relocation lies at the intersection of historical preservation, modern development, environmental sustainability, and engineering excellence. Finding a harmonious solution that addresses these diverse concerns is a

significant challenge. It requires innovative approaches, effective project management, and interdisciplinary collaboration to navigate the complexities of each unique relocation project successfully.

III. NEED FOR STRUCTURE RELOCATION

In Maharashtra, the need for structure relocation is particularly pressing due to the state's rapid urbanization and the associated demands for infrastructure development. Cities like Mumbai, Pune, and Nagpur are experiencing exponential population growth, creating a compelling requirement to reposition structures to accommodate new roads, transportation systems, and public spaces. This urban expansion necessitates a delicate balance between modern development and historical preservation. Historical sites and heritage structures dot the state, and safeguarding them often requires their careful relocation to allow for urban progress while preserving Maharashtra's rich cultural legacy.

Additionally, Maharashtra faces environmental challenges, including flood-prone regions, landslides, and coastal erosion. In such areas, relocating structures becomes imperative for the safety and resilience of communities. The state's commitment to mitigating disaster risks is a driving force behind relocating vulnerable structures away from hazard-prone zones, safeguarding both lives and property. Balancing urban development, heritage preservation, and environmental concerns, structure relocation in Maharashtra is an essential tool to manage growth, mitigate risks, and uphold the state's cultural and historical identity.



Fig 3.1

IV. POTENTIAL OF STRUCTURE RELOCATION



Fig 4.1

Structure relocation is a versatile and valuable technique with the potential to address a range of societal needs. One of its most prominent applications is in historic preservation. Moving historic buildings can help maintain cultural heritage while accommodating modern urban development. This approach ensures that the architectural and historical significance of these structures is not lost, contributing to a sense of continuity and identity within communities. Moreover, structure relocation plays a crucial role in disaster mitigation. In regions prone to natural disasters such as floods, earthquakes, or hurricanes, relocating buildings can significantly reduce damage and save lives. This proactive approach not only protects the well-being of residents but also minimizes the economic and environmental impacts of such disasters. Infrastructure projects also benefit from structure relocation. When constructing new roads, bridges, or public facilities, moving existing buildings can be a cost-effective solution. Rather than demolishing and rebuilding, relocating structures allows for the efficient use of resources and minimizes disruption to the surrounding environment. Environmental conservation is another domain where structure relocation shines. By moving structures away from ecologically sensitive areas, it helps protect natural habitats and reduces urban sprawl. This approach fosters a harmonious coexistence between human development and the environment, emphasizing sustainability and ecological responsibility.

V. LITERATURE SURVEY

A comprehensive literature survey on structure relocation reveals a diverse and well-documented field of study. Researchers and experts have explored various facets of this practice, ranging from the technical aspects of relocation techniques, including

hydraulic jacks and innovative methods like self-propelled modular transporters, to their applications in historical preservation. The literature places a strong emphasis on the preservation of cultural heritage, presenting numerous case studies of historic buildings that have been successfully moved to new locations. Additionally, it delves into the critical role of structure relocation in disaster mitigation, outlining the benefits in terms of risk reduction and economic savings. The impact on urban development and infrastructure projects, where relocation can streamline construction and minimize disruption, is another prominent theme. Researchers also highlight the environmental benefits of structure relocation in protecting natural habitats and curbing urban sprawl. Furthermore, the literature scrutinizes the economic implications of property development, where relocating buildings can enhance property values. It does not shy away from addressing the challenges involved, including structural integrity, regulatory hurdles, and community considerations. Case studies are a common feature, providing real-world insights into successful projects. Sustainability and social aspects, such as environmental impact and community well-being, are also explored. In summary, the literature on structure relocation serves as a comprehensive resource, offering insights, case studies, and expertise on a range of topics for researchers, practitioners, and policymakers alike.

- **Thomas W. Schmid (2018)**, states that in mountainous areas, urban development often takes place on slow-moving ground, which over time may inflict severe damage on buildings and infrastructure. This process can be accelerated significantly by new construction near existing structures. Although for stable ground conditions, the problem of excavation-induced damage has been studied extensively, for slow-moving landslides the question of how to reduce damage to neighbours remains open. This paper presents a general finite-element modelling procedure which allows for a full-scale investigation of the landslide excavation problem. The evaluation of structural damage follows an existing approach, in which the effect on the neighbouring buildings is deduced from greenfield displacements, using the limiting tensile strain method, correlated with damage categories. The results of the study, which was inspired by real landslide cases, show that failing to estimate the correct compression state of the landslide can lead to significantly higher damage to close neighbours than in the case of a stable slope. Designing the anchors close to the true in situ earth pressure reduces the damage potential, but can result in enormous anchorage costs if situated in a compressed landslide zone. Excavating farther from neighbours allows for a significant reduction in the required anchor support, which the proposed procedure helps to quantify. Another distinctive feature of excavations within landslides is the development of considerable compressive strains in the sliding direction along the lateral sides of the excavation. It is shown that these compressive strains also have the potential to damage neighbouring buildings.
- **Timothy R. Siegel (2019)**, Stated that Post-disaster migration patterns have been thoroughly studied from a demographic standpoint, but affected community residents' perceptions of ongoing risks and their willingness to remain in an affected community remain under-researched. Using data generated by 407 surveys and 40 interviews with residents impacted by the 2013 Calgary flood, this study analyses the effects of flood experience on residents' worry about future floods and their ensuing short-term and medium-term mobility plans. The results indicate that home flooding and evacuation orders are both predictive of worry about future floods. In turn, worry about future floods as well as age, homeownership, and place attachment are all predictive of post-disaster mobility plans. Residents discuss how the flood either strengthened or weakened their place attachment. The paper concludes by discussing the implications for social science research and for public policy that aims to mitigate disaster risk.
- **Ronald W. Anthony (2020)**, Stated that for centuries, historic structures have made a significant contribution to shaping the cultural landscape of local communities all around the world. Many people recognize the need to preserve existing and historic structures as they are part of the history and heritage of many local communities as well as whole countries. From buildings to bridges, preserving historic structures for current and future generations requires an interdisciplinary effort. Through a broad range of topics, this special collection illustrates and discusses assessment methodologies, analysis procedures, and conservation strategies used across different disciplines to achieve successful preservation. Readers are encouraged to check the collection frequently as additional papers for this collection will be added as they are accepted and published online.
- **David Biggs (2021)**, States that at the heart of this research agenda is an understanding that the state is something more than a collection of people or a series of institutions. To exist, a state needs subjects institutions and laws, but it also needs symbols territory and, most importantly, facts on the ground. Biggs never wades too deeply into a theoretical discussion of state-making or nation-building. He briefly cites Michel Foucault's governmentality and Gilles Deleuze and Félix Guattari's schizophrenic spaces. Instead, Biggs uses the sedimented artefacts of state making, the instruments of measurement and the earth-moving machines, the technologies that make space legible and thus governable, to tell a story about the repeated attempts to "concretize," "harmonize," and "stabilize" the Delta and its people. Quagmire is a story about the tension between a series of attempts to find the Delta's "final form" and the incessant eco-logic of the Delta itself, a logic that bends even steel and concrete toward movement and flow. The result, so similar to other famous flood control projects (the levees and spillways of southern Louisiana come to mind), is a "work of Penelope," a never-ending hydraulic engineering project. And it is this project that necessitates and justifies what Biggs describes as a hydraulic bureaucracy.

5.1 Methods Involved In Structure Relocation

1. Lifting and Sliding:

The lifting and sliding method is a fundamental technique in the field of structure relocation. It involves the careful elevation of a building, typically using hydraulic jacks, to create enough space beneath it. This process requires meticulous planning and coordination, ensuring that the building is raised uniformly to maintain its structural integrity. Once elevated, a system of tracks or rails is usually placed beneath the structure to facilitate the sliding phase. The building is then gently moved horizontally to its new location along these tracks. This method is well-suited for relatively smaller structures and shorter moves, as it offers a controlled and precise means of relocating buildings while minimizing the risk of damage.

One of the notable advantages of the lifting and sliding method is its versatility. It can be used in a variety of scenarios, from historic preservation projects to disaster mitigation efforts. The method allows buildings to be shifted to accommodate new developments, all while preserving the structural integrity and architectural character of the structure. The lifting and sliding approach exemplifies the combination of engineering precision and finesse, making it an essential technique in the toolkit of professionals involved in the complex and intriguing field of structure relocation.

2. Rolling:

The rolling method is a time-tested and efficient technique employed in the complex task of structure relocation. This method is particularly well-suited for relatively shorter moves and buildings that are not too large or heavy. It involves the use of specially designed steel rollers placed beneath the building. The structure is gradually rolled to its new location, propelled either manually or through mechanical means. While seemingly straightforward, the success of the rolling method lies in the precise coordination and control that must be maintained to ensure the building's stability and safety during the move.

What makes the rolling method advantageous is its simplicity and cost-effectiveness for smaller relocation projects. It minimizes the need for extensive and expensive equipment, making it a practical choice in certain scenarios. Additionally, this method has been employed in a range of settings, from moving residential homes to relocating smaller commercial structures, contributing to urban development, infrastructure projects, and disaster mitigation efforts. While not suitable for every situation, the rolling method remains a valuable tool in the repertoire of structure relocation professionals, demonstrating that sometimes the simplest solutions can be the most effective.

3. Hydraulic Transporters:

The hydraulic transporters method represents a highly advanced and sophisticated approach to structure relocation, particularly suited for large and heavy buildings. These transporters, known as Self-Propelled Modular Transporters (SPMTs), are equipped with hydraulic systems that allow for precise control and even weight distribution. The building is typically raised onto a set of these transporters, and each wheel can be independently controlled to navigate around obstacles, manage turns, and accommodate changes in terrain. This method is ideal for complex moves, such as the transportation of industrial facilities, large commercial buildings, or even historic structures with immense weight and size, as it ensures minimal structural stress during the relocation.

One of the primary advantages of hydraulic transporters is their ability to move extremely heavy loads with precision. The hydraulic systems provide fine-tuned control, ensuring that the building is transported smoothly and without undue strain on its structure. Additionally, these transporters can adapt to a wide range of scenarios, making them suitable for various project types. While this method requires a significant level of technical expertise and investment in equipment, it stands as a testament to the remarkable engineering achievements in the field of structure relocation, allowing even the most massive structures to be safely and efficiently moved to new locations.

4. Cut and Cover:

The cut and cover method is a specialized and intricate approach to structure relocation, commonly employed for large and complex buildings that need to be moved short distances. It involves meticulously dividing the structure into sections, which are then individually raised, transported, and reassembled at the destination. The process begins with the careful assessment of the building's structure to determine the most suitable locations for division. Once the building sections are identified, they are carefully separated along predetermined cut lines, and each part is subsequently prepared for movement. This method is often utilized in urban environments with limited space, where it's challenging to transport entire structures without causing significant disruption. The cut-and-cover method requires meticulous planning, engineering expertise, and precise coordination to ensure the structural integrity of the building is maintained throughout the relocation process.

5.2 Future Scope of Structure Relocation

- ✦ **Advanced Technology:** Continued innovation in equipment and technology will enable more precise and efficient structure relocations.
- ✦ **Sustainable Urban Development:** An increasing focus on sustainable urban planning will drive the relocation of structures to protect green spaces and promote eco-friendly development.
- ✦ **Historic Preservation:** The preservation of historical and culturally significant buildings will remain a driving force for relocation projects.
- ✦ **Climate Resilience:** Relocating structures away from flood-prone or disaster-prone areas will become more essential in the face of climate change.
- ✦ **Technological Integration:** The integration of digital tools like 3D modelling, virtual reality, and AI will enhance planning and execution.
- ✦ **Regulatory Frameworks:** Governments will likely establish clearer regulations for structure relocation to ensure safety and environmental responsibility.
- ✦ **Community Involvement:** Enhanced community engagement will be critical to gaining acceptance for relocation projects.

- ✦ **Urban Redevelopment:** Urban areas will continue to expand and evolve, necessitating optimized land use through structure relocation.
- ✦ **Disaster Mitigation:** Relocating structures as part of disaster mitigation strategies will become more common in vulnerable regions.
- ✦ **Infrastructure Projects:** Transportation and public infrastructure developments will drive relocation projects to make way for progress.
- ✦ **Environmental Conservation:** Efforts to preserve natural habitats and reduce urban sprawl will lead to more structure relocations.
- ✦ **Research and Education:** Educational programs and research in the field will grow to meet the increasing demand for skilled professionals.
- ✦ **Cost-Effective Solutions:** Economic considerations will continue to influence relocation decisions, ensuring cost-effectiveness.
- ✦ **Global Collaboration:** International collaboration among experts in structure relocation will facilitate knowledge sharing and best practices.
- ✦ **Adaptive Solutions:** The field will adapt to emerging challenges and opportunities, remaining at the forefront of sustainable and innovative urban development.

The future scope of structure relocation is marked by advanced technology, a strong emphasis on sustainability, and the preservation of cultural heritage. With the ongoing challenges posed by climate change and urbanization, relocation projects will increasingly focus on climate resilience, disaster mitigation, and eco-friendly urban development. Advanced digital tools and global collaboration will shape the industry, making projects more precise and efficient. Regulatory frameworks, community engagement, and economic considerations will play pivotal roles in the decision-making process. As urban areas evolve, structure relocation will continue to optimize land use, promote sustainability, and foster economic growth, making it a vital component of future urban development and disaster preparedness.

VI. METHODOLOGY

The methodology of structure relocation is a multifaceted process that involves a series of carefully planned and executed steps. It typically commences with an exhaustive assessment of the building, where structural engineers and relocation experts evaluate its size, weight, structural integrity, and the conditions of its foundation. This initial inspection helps determine the most suitable relocation method and the extent of any structural reinforcement required. Once the assessment is complete, the preparation phase begins, which includes the installation of supports and the strengthening of the building. This phase also involves securing the necessary permits and addressing any regulatory requirements specific to the project's location.



Fig 6.1

The actual relocation process consists of lifting or elevating the structure, whether using hydraulic jacks, lifting equipment or other specialized methods subsequently moving it to the new location. During this phase, precision and coordination are paramount, ensuring the building remains stable and its structural integrity is preserved. After reaching the new site, the structure

is carefully lowered or placed onto its new foundation. The final stages involve the reconnection of utilities and the restoration of the building's functionality. Throughout this methodology, safety measures, community considerations, and environmental protection are central, making structure relocation a comprehensive and precise undertaking that demands a combination of engineering expertise and logistical proficiency.

- Site assessment
- Site planning
- Site preparation
- Lifting
- Transport
- Precise coordination
- Foundation
- Reconnection
- Restoration
- Safety measures
- Environmental protection
- Risk management
- Engineering expertise



Fig 6.2

6.1 Site Assessment

Site assessment is a fundamental aspect of structure relocation. This crucial phase involves a comprehensive evaluation of the current and new locations, including the existing building, the surrounding environment, and infrastructure. It helps identify any potential challenges or obstacles that might affect the relocation process, such as terrain, road access, and utilities. A thorough site assessment is essential for effective planning and ensuring a safe and successful structure relocation.

6.2 Site Planning

Site planning plays a pivotal role in structure relocation. It involves meticulous consideration of the new location, including foundation preparations, access routes, and utilities. This phase focuses on creating a clear and safe path for the building's transport, often requiring infrastructure adjustments or reinforcement. Effective site planning is essential to streamline the relocation process and ensure the building's secure placement at its new site.

6.3 Site Preparation

Site preparation is a critical phase in structure relocation, involving the readiness of both the current and new locations. This process includes ensuring that the building's foundation at the new site is appropriately constructed or modified to accommodate the structure. It may also encompass securing permits, clearing obstructions, and reinforcing the building for the impending move. Effective site preparation is essential for a smooth, safe, and successful structure relocation, minimizing risks and ensuring the building's structural integrity throughout the process.

6.4 Lifting

Lifting is a pivotal step in structure relocation, enabling the separation of the building from its foundation. Hydraulic jacks or specialized lifting equipment are employed to gradually elevate the structure, creating the necessary space beneath it for the relocation. This process demands precision and careful coordination to ensure the building's stability and integrity throughout the lifting procedure. Lifting is a critical element in the relocation methodology, setting the stage for the building's safe and controlled transfer to its new location.

6.5 Transport

Transport is a central phase in the complex process of structure relocation. Once the building is lifted or prepared for movement, it needs to be securely transported to its new location. Specialized transport equipment, such as hydraulic transporters or sliding systems, are often utilized to move the structure, depending on its size and weight. This step requires precision, with each movement carefully coordinated to ensure the building's stability during the journey. Transport is a critical stage, aligning the building for its final placement and restoration at the new site.

6.6 Precise coordination

Precise coordination is the linchpin of successful structure relocation. This meticulous planning and execution involve the synchronization of various aspects, including lifting, transport, and placement. Every movement must be carefully calculated to ensure the building's stability and structural integrity throughout the relocation process. Precise coordination demands expertise, a keen eye for detail, and a deep understanding of the building's specifications, making it a pivotal element in ensuring a safe and successful structure relocation.

6.7 Foundation

Foundation coordination is a critical component of structure relocation, focusing on the preparation and compatibility of the new site's foundation to receive the building. This phase often includes adjusting or reinforcing the foundation to align with the structure's weight and dimensions. Precise alignment and levelling are crucial to ensure the building's stability upon placement. Effective foundation coordination is key to a successful relocation, safeguarding the structural integrity of the building during the move and at its new location.



Fig 6.3

6.8 Reconnection

Reconnection is a crucial phase in structure relocation, where utilities and services are carefully re-established to ensure the building's functionality at its new location. This process involves the reattachment of essential systems such as electricity, plumbing, and HVAC, following their temporary disconnection for the move. Precise coordination and expert reconnection efforts are necessary to guarantee a seamless transition and that the building is fully operational post-relocation. Successful reconnection plays a vital role in minimizing downtime and ensuring the structure is ready for its intended use.

6.9 Restoration

Restoration is a pivotal phase in the structure relocation process, involving the meticulous repair and revitalization of the building to its original or desired condition. This stage encompasses tasks like repairing any structural or cosmetic damage incurred during the relocation, as well as making any improvements or upgrades as needed. The goal is to ensure that the building is not only functional but also aesthetically pleasing and ready for its intended purpose. Effective restoration is essential for a successful structure relocation, as it ensures the building's seamless reintegration into its new environment, whether that's for residential, commercial, or historical use.

6.10 Safety measures

Safety measures are of paramount importance throughout every phase of structure relocation. This comprehensive process involves the lifting, transport, and placement of large buildings, and it inherently carries certain risks. To mitigate these risks, rigorous safety protocols are established and followed. These measures encompass securing the site, ensuring the structural integrity of the building, safeguarding workers and the public, and adhering to industry standards and regulations. Safety is a top priority in structure relocation, and strict adherence to safety measures is essential to protect lives, property, and the environment during these complex projects.

6.11 Environmental protection

Environmental protection is a critical consideration in structure relocation, especially in today's environmentally conscious world. Relocating a building can have environmental impacts, so measures are taken to minimize these effects. This includes precautions to prevent soil and water contamination, minimize disruption to natural habitats, and ensure that hazardous materials are handled responsibly. Eco-friendly practices such as recycling materials and energy-efficient transportation methods are often incorporated to reduce the project's carbon footprint. Environmental protection is not just a legal requirement but also a moral responsibility, ensuring that structure relocations are conducted with due regard for the surrounding ecosystem and future sustainability.

6.12 Risk management

Risk management is a fundamental aspect of structure relocation, addressing the inherent challenges and potential hazards involved in moving large buildings. Thorough risk assessments are conducted to identify and evaluate possible scenarios, including structural failures, equipment malfunctions, and unexpected obstacles. Risk mitigation strategies are then developed, which may involve contingency plans, safety measures, and emergency response procedures. The goal of risk management is to

ensure that potential issues are anticipated and addressed, safeguarding the safety of workers, the integrity of the building, and the success of the relocation project.

6.13 Engineering expertise

Engineering expertise is at the core of successful structure relocation projects. Structural engineers and specialists play a pivotal role in assessing the building's integrity, determining the most suitable relocation methods, and overseeing the entire process. Their deep knowledge of materials, loads, and structural systems is critical in ensuring the building's stability throughout the move. Additionally, they are instrumental in addressing unforeseen challenges, adapting plans, and making real-time decisions to guarantee a safe and efficient relocation. The intricate nature of structure relocation demands a high level of engineering proficiency, making these professionals indispensable to the success of such projects.



Fig 6.4

VII. Conclusion

Structure relocation is a complex and multifaceted field that has evolved significantly over the years, driven by a combination of technological advancements, urban development needs, and environmental considerations. In this article, we have explored the various aspects of structure relocation, from the meticulous planning and preparation phases to the precise coordination and execution of moving large buildings. The methodology behind structure relocation encompasses an array of specialized techniques, from lifting and rolling to the use of hydraulic transporters, all tailored to the unique characteristics and requirements of each project.

The future scope of structure relocation holds promise, as cities continue to grow, climate resilience becomes a priority, and historical preservation gains significance. Sustainability, urban redevelopment, and disaster mitigation are set to shape the industry's landscape. We can anticipate a greater integration of advanced technology, environmental consciousness, and community engagement in relocation projects. As we look ahead, the industry will remain dynamic, responding to evolving challenges and opportunities, offering solutions for smarter urban development, disaster preparedness, and the preservation of our historical heritage.

At the heart of this endeavour is an unwavering commitment to safety, environmental protection, and the highest standards of engineering expertise. Structure relocation is more than just moving buildings; it's about reshaping urban landscapes, preserving our past, and creating a sustainable future. With each relocation project, we find a balance between the old and the new, between progress and preservation, and between the challenges and the solutions that make this field a testament to human ingenuity and the possibilities of reimagining our cities.

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