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Cost-effective and energy-efficient building using the rammed earth technique in south east Nigeria: Challenges and prospects

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Abstract

As global concerns about sustainability and energy efficiency in construction grow, the rammed earth building technique presents a compelling option. This traditional method of building, practised widely traditionally in the past in the South East of Nigeria in the form of cob, is known for its low environmental impact and cost-effectiveness. Rammed earth building is experiencing a renaissance in modern architecture. This article examines the economic and energy benefits of rammed earth construction, its challenges, and future prospects. By addressing technical, regulatory, and perceptual barriers, we explore how this ancient technique can meet contemporary demands for sustainable building solutions in the region.

Keywords: Sustainability, Energy efficiency, Cost-effectiveness, Building technique, Local material, Perception.

1. Introduction

The construction sector is a significant contributor to global carbon emissions, prompting a search for sustainable building materials and methods. Rammed earth, an ancient technique involving the compaction of lateritic soils between form-work to create durable walls, offers a low-carbon alternative to conventional materials like concrete and steel. This method utilizes abundant locally available soil, reducing transportation costs and emissions, while also providing excellent thermal mass, which can lead to energy savings (Houben & Guillaud, 1994). Knowing that this method of construction is not yet in use in Nigeria, this article explores the economic and energy efficiencies of rammed earth, alongside the challenges it faces in broader adoption in the third world countries like Nigeria.

In Nigeria, lateritic soils are of great interest to the construction Industries due to its natural abundance, availability and favourable engineering properties. They are useful materials for construction of foundation, roads, airfields, low-cost housing and compacted fill in earth embankments (Bonnaccorsi, A. 1992).

Rammed earth building is a great choice for low-cost housing in South-East Nigeria. It is a sustainable and cost-effective construction technique that utilizes abundant locally available soil rich in clay, thereby reducing overall expenses. Rammed earth construction relies on the use of compacted soil mixed with a small amount of cement or stabilizer where necessary. Since South-East Nigeria has this abundant soil resources, this building technique takes advantage of this locally available materials, minimizing transportation costs.

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2. Cost-Effectiveness of Rammed Earth Construction

2.1. Initial Material Costs

Rammed earth is often celebrated for its potential cost savings, particularly in areas where suitable soil can be sourced locally like in south east Nigeria. The primary cost components include soil, form-work, and labour. Unlike concrete, which requires significant amounts of energy-intensive cement, rammed earth can often utilize natural soil with minimal additives. This reduces material costs significantly, especially when local soils meet the required specifications for strength and stability (Easton & Easton, 2007).

2.2. Labour and Equipment

While materials may be inexpensive, rammed earth construction is labour-intensive. Skilled labour is essential for mixing, compacting, and curing the earth correctly. The need for specialized equipment, such as pneumatic rammers, or hand held locally made rammers can also add to the initial costs. However, as skill levels increase and technologies improve, these costs decreases. Moreover, the reuse of form-work across multiple projects can amortize the initial investment (Minke, 2009).

2.3. Long-term Cost Savings

One of the most significant financial advantages of rammed earth is its durability and low maintenance requirements. Rammed earth walls are resistant to fire, pests, and weathering, reducing the need for repairs and replacements. The method's longevity, often surpassing that of conventional buildings, translates into lower life-cycle costs (Walker et al., 2005). Additionally, the thermal mass properties of rammed earth can lead to substantial energy savings by reducing the need for heating and cooling, thereby lowering utility bills over time.

3. Energy Efficiency and Environmental Impact

3.1. Thermal Performance

The thermal mass of rammed earth walls provides natural insulation, stabilizing indoor temperatures. This property allows the walls to absorb heat during the day and release it at night, minimizing temperature fluctuations and reducing reliance on artificial heating and cooling systems. This passive thermal regulation contributes significantly to energy efficiency, making rammed earth buildings suitable for various climates (Jaquin et al., 2009).

3.2. Embodied Energy

Embodied energy refers to the total energy required for the extraction, processing, manufacture, and delivery of building materials. Rammed earth generally has low embodied energy compared to materials like concrete and steel. The use of local soils further reduces the carbon footprint associated with transportation. In cases where stabilization with cement or lime is necessary, the embodied energy increases but remains lower than that of conventional construction materials (Minke, 2009).

3.3. Environmental Benefits

In addition to low embodied energy, rammed earth construction offers several environmental benefits. The technique uses natural and often local materials, which reduces the environmental impact of material production and transport. Moreover, the buildings can be designed to be recyclable or biodegradable, further enhancing their sustainability. The minimal use of synthetic chemicals and the potential for incorporating waste materials into the mix also contribute to its environmental appeal (Houben & Guillaud, 1994).

4. Challenges in Rammed Earth Construction

4.1. Technical Challenges

Not all soils are suitable for rammed earth construction. The ideal soil mix contains a specific ratio of sand, silt, and clay. If the local soil does not meet these requirements, stabilizers such as cement or lime must be added, which can increase costs and the building's embodied energy. Additionally, the compaction process requires precise control to ensure structural integrity, demanding skilled labour and quality equipment (Jaquin et al., 2009).

4.2. Structural and Seismic Concerns

Rammed earth buildings are heavy, which poses challenges in earthquake-prone areas. The material's natural brittleness requires careful engineering to enhance seismic performance. Solutions include the integration of horizontal and vertical reinforcement, hybrid construction techniques, or the use of flexible joint systems. These measures, however, can increase costs and complexity (Walker et al., 2005). However, Nigeria is not within seismic region.

4.3. Regulatory and Code Compliance

Building codes in many regions do not accommodate alternative materials like rammed earth. This regulatory gap can lead to increased time and costs for approvals and permits, as builders may need to prove the material's suitability and safety. The lack of standardized building codes and practices can also result in inconsistent construction quality, posing challenges for wider adoption (Easton & Easton, 2007).

4.4. Perception and Market Acceptance

Despite its benefits, rammed earth construction often faces scepticism. In some areas, it is perceived as a low-status or primitive building method, unsuitable for modern applications. This perception can be a significant barrier to market acceptance, requiring educational initiatives to highlight the technique's advantages in sustainability and cost-effectiveness. Overcoming these biases is crucial for the broader adoption of rammed earth in mainstream construction (Minke, 2009).

5. Prospects for Rammed Earth Construction

Advancements in construction technology offer potential solutions to some of the challenges faced by rammed earth. The development of improved soil stabilization techniques, such as the use of chemical or natural additives, can enhance the material's strength and durability. Innovations in form-work design and compaction methods can also streamline the building process, making it more efficient and less labour-intensive. Digital tools like Building Information Modelling (BIM) can assist in precise planning and design, ensuring that rammed earth projects meet modern standards and expectations (Walker et al., 2005).

5.1. Integration with Modern Design

Rammed earth can be successfully integrated into contemporary architectural designs, providing a unique aesthetic that combines rustic charm with modernity. Architects are increasingly exploring hybrid structures that incorporate rammed earth with materials like glass, steel, and wood. This fusion not only enhances the visual appeal but also allows for the integration of advanced building systems and technologies, making rammed earth suitable for a wide range of applications from residential to commercial projects (Easton & Easton, 2007).

5.2. Policy and Incentives

Government policies and incentives play a crucial role in promoting sustainable construction practices. By recognizing the environmental benefits of materials like rammed earth, governments can offer incentives such as tax reductions, grants, or expedited permitting processes. These incentives can offset some of the initial costs and help make rammed earth more competitive with traditional building methods. Additionally, the establishment of clear guidelines and standards for rammed earth construction can facilitate its acceptance in the regulatory framework (Houben & Guillaud, 1994).

5.3. Educational and Training Programs

For rammed earth to gain wider acceptance, there needs to be a concerted effort to educate architects, engineers, and builders about the technique. Universities and technical colleges can incorporate courses on sustainable building methods, including rammed earth, into their curricula. Professional organizations can offer workshops and certification programs to enhance the skills and knowledge required for rammed earth construction. This educational

push is essential for overcoming the technical and perceptual barriers that currently limit the technique's adoption (Minke, 2009).

6. Conclusion

Rammed earth construction offers a promising alternative to conventional building methods, providing cost-effective and energy-efficient solutions that are environmentally sustainable. Despite facing challenges such as technical limitations, regulatory hurdles, and market perceptions, the prospects for rammed earth are bright. With ongoing technological innovations, supportive policies, and increased educational efforts, rammed earth has the potential to play a significant role in the future of sustainable architecture. As the construction industry in the region continues to seek ways to reduce its environmental impact, the ancient technique of rammed earth presents a viable and compelling path forward. This comprehensive examination of rammed earth construction highlights both its potential and challenges, providing a balanced view that can inform practitioners, policy-makers, and academics. By addressing the barriers and exploring future directions, this article contributes to the ongoing discourse on sustainable building practices.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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