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Exploring Earth-Building Techniques with Local Knowledge Holders in Siaya County, Kenya

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Abstract
Earth construction techniques such as wattle and daub, adobe, compressed earth blocks (CEB), cob, and rammed earth offer sustainable and cost-effective solutions for building in various contexts. This study investigates the feasibility of implementing these methods with local citizens, focusing on the adaptability, accessibility, and challenges of each technique. The research evaluates the step-by-step processes and resource requirements, and skill demands involved in their execution. By conducting field experiments and engaging communities in hands-on workshops, the study identifies key factors influencing successful construction, including material preparation, tools, and supervision. The findings highlight the potential of these earth-building techniques to empower local communities, and promote environmentally friendly construction practices. Recommendations are made for optimizing workflows and community engagement strategies to ensure broader adoption and scalability. This work contributes to the discourse on sustainable architecture by demonstrating how individuals can play an active role in creating durable and culturally resonant structures using local resources.

Keywords: *earth building techniques; building process; community practice; Kenya; sustainable architecture*

1. Introduction

The demand for sustainable construction solutions has never been more urgent, as the global building sector faces increasing pressures from climate change, resource depletion, and rapid urbanization (Franziska Schreiber et al., 2023). In this context, traditional earth construction methods are regaining significant attention and interest (Dejeant et al., 2021). Time-tested vernacular techniques, such as wattle and daub, adobe, compressed earth blocks (CEB), cob, and rammed earth, align closely with principals of ecological balance, affordability, and low environmental impact (Rong & Bahauddin, 2023; Zawistowski et al., 2020). Especially, CEB is seen as a modern alternative to traditional techniques with benefits like consistency of quality, increased compressive strength due to compression, highly flexible in forming the brick design, and usable for rural and urban structures (Guillaud, 1995). Several studies underscore the potential of earth-based techniques to reduce carbon emissions and improve thermal comfort in buildings (Pacheco-Torgal & Jalali, 2012; Keena et al., 2022; Ouedraogo et al., 2024). The technical properties can also keep pace with industrial building products if they are designed and constructed correctly. The use of fibres or stabilizers like lime can even enhance them and reduce shrinking rations. The mechanical properties are also significantly improved by adding cement (Proterra et al., 2009). This should be viewed critically due to its poor life cycle assessment values and the contamination of the soil during deconstruction, as the two materials, cement and soil, can no longer be separated from each other. Despite their advantages, the scalability and broader adoption of earth construction methods remain limited. Challenges of building with earth such as inconsistent material quality, labour intensity, and a lack of standardized practices and technical skills often hinder their widespread application (Rojat et al., 2020). Another factor is the negative association of earth buildings with poverty among the population (Barbacci, 2020). These challenges can be countered with participatory building processes. Community of practices (CoPs) in building construction offers several positive aspects. It fosters connections among individuals, groups, and organizations (Weil, 1996); strengthens connections to places; and nurtures a sense of empowerment and self-worth (Melcher, 2020). The participants acquire technical skills and communication skills (Holmes & Woodhams, 2013). This also includes the transfer of knowledge, which takes place automatically and positively between participants of different or the same generation (Ruikar et al., 2009). Participative building processes have become prominent for involving local communities in designing and constructing their environments. This approach democratizes the building process and ensures structures meet users' specific needs and preferences. Citizen involvement fosters ownership, appreciation, and responsibility, resulting in more sustainable and accepted outcomes. (“Architektur – Gemeinschaft B.R.O.T.-Pressbaum,” n.d.). This paper examines earth construction methods in local communities to promote sustainable architecture. In a workshop with Sauti Kuu Foundation participants in Nyangoma Kogelo, the study evaluated the efficiency, tool needs, and scalability of different techniques. By tackling practical challenges and enhancing adaptability, the research aims to develop strategies for wider adoption. The findings emphasize community-driven, low-impact practices that boost local resilience and inclusivity, offering scalable solutions to global sustainability challenges.

2. Methodology

2.1. Location

The workshop was collaboratively developed and conducted with the Sauti Kuu Foundation and local citizens actively involved with the Foundation. These participants are members of the Luo community from Siaya County in eastern Kenya, near Lake Victoria. The Luo are one of Kenya's most prominent ethnic groups, renowned for their rich cultural heritage. Traditionally, the Luo constructed their homes using the Wattle & Daub technique, which remains prevalent today. The building workshop was held on the grounds of the Sauti Kuu Foundation in Nyangoma Kogelo. The subsequent illustration (Fig. 1) indicates the orientation of the sample walls, highlighted in red, along with the workshop site.

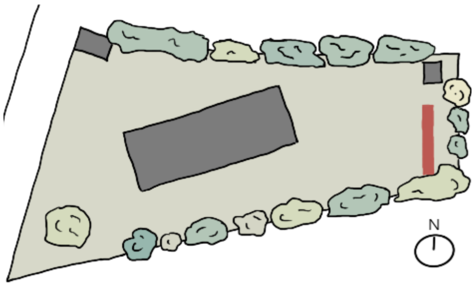

Fig. 1 – *Orientation of sample walls on workshop site.*

2.2. Workshop set-up

In this workshop, which was jointly facilitated with the Sauti Kuu Foundation, 5 different earth construction techniques were tested within the community, including wattle & daub, cob, rammed earth, compressed earth blocks and adobe.

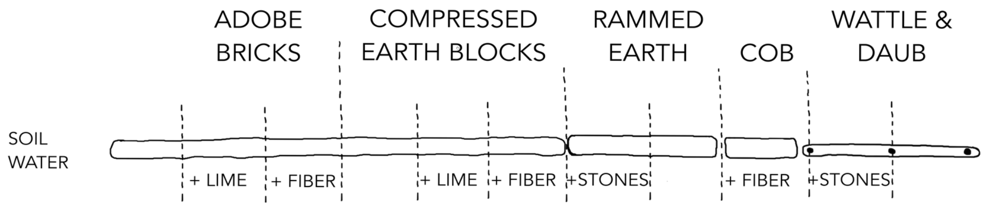

Fig. 2 – *Schematic sketch of test wall arrangement.*

Each wall sample measured 0.5m in height and 1m in length, with slight variations in width. The walls were built with the help of 61 people, all beneficiaries of the Foundation. This included adults (31) and children (30).

To accommodate the drying period for clay bricks and compressed earth blocks, the workshop was divided into two sessions, spaced seven days apart. During the introduction, building techniques were explained, supplemented by a YouTube video demonstration ("Building with Mud: A Continuum - YouTube," n.d.). Each construction process for the model wall was illustrated on A3 paper. Participants were divided into five mixed-age groups, each focusing on a different construction method. The test walls were built following the scheme in Fig. 2. For Adobe and CEB, three walls were made: one with only soil, one with lime stabilizer, and one with fibres. The two rammed earth samples, with only soil and with stone layers, were constructed together. Only one cob wall and two wattle & daub walls (one with stone infill and one with plain soil) were built.

2.3. Building processes

For the building process and time measuring it was ensured that the required building materials are available and ready on the construction site as well as the necessary tools.

- **Wattle and daub**: The wattle and daub technique is the most well-known and is widely used in both modern and traditional Luo construction. It requires minimal tools, namely a machete and a digging pole. For a sturdier wall, two wooden wattles were positioned about 15 cm apart and bound together with locally sourced sisal fibres. One section of the two-meter test wall was filled with stones and the other with soil (Fig. 3). After a week, it was plastered with a traditional earth and cow dung mixture.

Fig. 3 – *Wattle & Daub group with finished test wall.*

- **Cob:** For the cob construction technique, a 0.5-meter-deep hollow was excavated 2 meters away from the test wall site. Initially, the vegetation layer was removed and set aside. The loose soil was then combined with dry Vetiver fibres found on-site, which were trimmed to lengths of 10–15 cm (Fig. 4). This mixing process was done manually, using hands and feet. The prepared cob mixture was then carried by hand to the test wall location, where it formed a structure approximately 35–40 cm wide (Fig. 5). The mixed earthen lumps were placed layer by layer, both side by side and on top of one another. Finally, a machete was used to smooth the sides of the wall.

Fig. 4 – *Preparation of Cob Mixture.*

Fig. 5 – *Cob building in process.*

- **Rammed earth:** For constructing the rammed earth wall, a two-meter-long formwork was created from wooden screen-printing panels. These panels were reinforced with Markhamia lutea (Siala) wood stakes, which were driven into the ground and secured with nails at the sides. The formwork's ends were enclosed with additional screen-printing panels, as shown in Fig. 6. The formwork was filled with 15 cm of on-site soil and compacted using a homemade wooden rammer. Soil was sourced 2–3 meters from the test wall, utilizing the subsoil after removing the top 30-50 cm. Per the ESRI geographical soil map, this soil is clay-rich (with approx. 50%) (Esri environment and GIS User Community 2023). Due to budget constraints, no additional sand was incorporated, though adding sand would reduce stress cracks and enhance compressive strength. The recommended practice is to analyse local soil samples in a laboratory to determine the optimal mixing ratio. However, to focus on practical construction and because the test wall was only 0.5 meters high, this step was skipped. After tamping the first layer, gravel was added to one 1-meter-long side, followed by the placement and tamping of another 15 cm of loose soil. This sequence was repeated until the wall reached 50 cm in height.

Fig. 6 – *Group of rammed earth building process with finished framework.*

- **Adobe:** The soil excavated from the construction site was prepared for the adobe bricks. This mixture was then placed into a handmade wooden adobe formwork (Fig. 7). Using a board, the adobe bricks were carefully lifted from the mold (Fig. 8) and placed on the nearby meadow to dry. To prevent direct sunlight exposure and minimize stress cracks, the bricks were covered with hay. For each variation - one with only soil, one mixed with lime (soil/lime 6:1), and one with fibre - 20 bricks were produced. After a week of drying, they were assembled using a soil/lime mortar.

Fig. 7 – *Adobe framework, fabricated by Jacob Wanjala Wakoli.*

Fig. 8 – *Preparation of Adobe bricks.*

- **Compressed earth blocks (CEB):** The CEBs were produced on-site using the Makiga Press (Fig. 9). The soil was sourced directly from the construction site, adjacent to the test wall location, and was used without further processing. Three distinct test walls were constructed using this method: the first using only soil, the second incorporating fibres, and the third supplemented with lime (soil:lime - 6: 1). For each 1-meter-long test wall variation, 21 bricks were pressed. Once pressed, the bricks were left to cure on-site for a week. After this drying period, they were assembled using a slurry of earth-lime mortar.

Fig. 9 – *Infilling process of the "Makiga" CEB Press.*

2.4. Evaluation

Firstly, the time participants spent on each technique was analysed and compared. Using this data, the additional time needed to increase the height of a 1-meter wall to 2 meters was estimated to assess the work processes of different construction methods. The number of tools required, and formwork complexity were also evaluated. Formwork complexity was rated on a scale of 1 to 3 points: 1 indicates low complexity, 2 indicates medium complexity, and 3 indicates high complexity.

3. Results

3.1. Construction time during workshop

The graph in Fig. 10 illustrates the active construction time (excluding curing) from the workshop's first two days. On day 1, adobe and compressed earth blocks (CEB) were made and set to dry; on day 2, these dried bricks were assembled into the sample wall. Fig. 10 reveals that constructing a 1 m wide, 0.5 m high rammed earth wall is the most time-consuming compared to cob and wattle & daub. Though adobe and CEB production are quicker, they require curing time. Cob is the fastest method, but layer drying should be considered for taller walls. The traditional Luo wattle & daub technique is the second fastest.

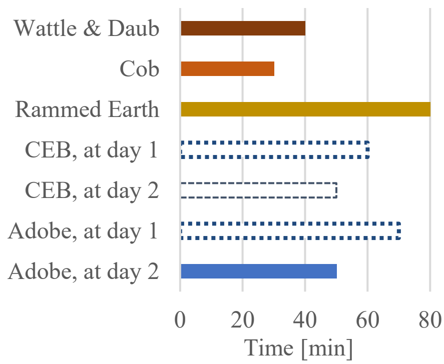

Fig. 10 – *Construction time of different earth building techniques during workshop day 1 and day 2.*

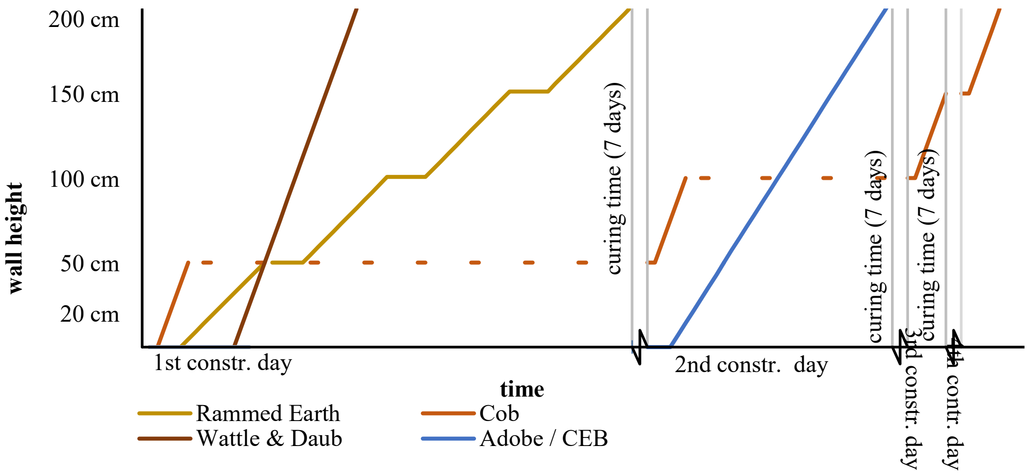

Fig. 11 – *Estimated construction time of different earth building techniques for building a 1 m wide and 2 m high wall.*

3.2. Estimated construction time for a 2 m high wall

The workshop time was used to estimate the construction time for a 2-meter wall using each technique. Since the methods involve different processes (active and passive construction time), the graph (Fig. 11) shows that faster initial construction leads to longer curing phases, resulting in a longer total process. For instance, the cob method builds in 50 cm layers, requiring each to dry before the next can be added, significantly extending the total construction time despite being the fastest method in the workshop. The production of adobes and compressed earth blocks (CEB) requires a drying period, with bricks made on one day and assembled the next. The fastest method is traditional wattle & daub, followed by rammed earth. An additional advantage of wattle & daub is that once the timber structure is up, the roof construction can begin, unlike with other techniques.

3.3. Tools required

All techniques use a digging pole for soil preparation (Tab. 1). Wattle & daub and cob require the least materials, needing only a machete for timber or fibre preparation; other tasks are done manually. Adobe involves a simple handmade mold, while compressed earth blocks use the "Makiga" machine, which is easy to operate with brief training. Rammed earth is the most complex, requiring numerous tools like a hammer, spanner, and tamper, as well as careful formwork assembly and disassembly to prevent damage.

4. Discussion

4.1. Optimizing & skill demand

- **Preparing Soil:** The use of additional construction machinery can accelerate building processes and reduce physical labour, particularly in soil preparation. However, it increases costs and requires skilled operators. Moreover, heavy machinery may compromise site safety—especially where child participation, essential for educational and empowerment goals of the Sauti Kuu Foundation, is intended.

- **Wattle & Daub/Cob:** These techniques are well-established and allow for rapid implementation. At this stage, process optimisation is not a priority. However, subsequent investigations may focus on enhancing the long-term durability of the construction system.

Table 1 - *Required tools for each construction technique.*

	Digging pole	Machete	Shovel	Hammer	Tamper	Formwork Complexity
Wattle & Daub	•	•				
Cob	•	•				
Rammed Earth	•		•	•	•	•••
Compressed Earth Block	•		•			••
Adobe	•					•

- **Rammed earth:** To optimise the workflow of rammed earth construction, the experiment demonstrated that improved formwork design is essential to facilitate handling and assembly. Moreover, the presence of a skilled trainer on-site is critical to guide workers in achieving the appropriate soil consistency, which is vital for structural stability and long-term durability.
- **Adobe/CEB:** Both adobe and compressed earth block (CEB) techniques require initial training, particularly in determining the appropriate soil-to-binder mixing ratio and in the correct handling of equipment, whether operating the press or placing soil accurately within the formwork. However, CEB benefits from a more consistent brick quality by using the same pressing machine each time (Guillaud, 1995), whereas Adobe, which relies on manual techniques, can result in varying degrees of quality.

4.2. Community engagement strategies

As exemplified by the Sauti Kuu Foundation, community engagement is key to advancing sustainable construction.

Participatory design fosters ownership, preserves indigenous knowledge, and builds local skills, while reducing stigma around earthen materials. Integrating traditional knowledge with modern engineering enhances the durability and performance of earth-based structures.

5. Conclusion

This study explored the construction time of five vernacular earth-building techniques—wattle & daub, cob, adobe, CEB, and rammed earth—through applied research with the Sauti Kuu Foundation in Nyangoma Kogelo. The results underscore the efficiency and contextual appropriateness of wattle & daub, a traditional Luo method, which outperformed others in speed and simplicity. While techniques like cob showed promise in controlled environments, their full-scale application revealed limitations in time efficiency. These findings demonstrate the continued relevance of vernacular methods in contemporary construction, particularly when locally adapted and community driven. Moving forward, integrating indigenous knowledge with modern performance criteria—such as structural durability, resource efficiency, and self-build potential—will be crucial. A holistic, interdisciplinary approach is needed to translate vernacular principles into scalable, sustainable, and culturally resonant solutions for today's-built environment.

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