

Conversation with Earth

*How a Swedish initiated earth school
project in The Gambia can contribute to
develop earth building in both contexts*

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Design Activism Beyond Borders | 2023

Abstract

Since time immemorial, humankind has used earth to construct dwellings. In industrialised countries, earth was discarded and replaced by other materials with the arrival of the industrial revolution. However, with the rising awareness of sustainability in the construction sector today, earth building is experiencing a revival as an affordable and sustainable construction method. Earthen materials are still used in large parts of the world, mostly in developing areas in the global south, but as a result of colonial heritage and the global development discourse in the mid-twentieth century, earth architecture is commonly viewed upon as an inevitable preliminary stage of development toward industrial society, rendering the notion of it symbolising temporality and under-development. In other words, stigmas and a lack of adaptation to industrialised processes is hindering use of earth in modern day construction.

In 2018, Eivor Björkman Gambia aid, Detail Group AB and EarthLAB studio initiated a project to build a school of rammed earth in Ghana Town, a poor fishing community in The Gambia. The goal is to provide education in the community and promote earth building in Gambian urban development.

With point of departure in practical learning and inter-disciplinary collaboration, this thesis explores the Gambian perspective on earth building and the nuances of a western architect doing work in The Gambia. What type of role can an international architect fill in this context? How to assist and elevate rather than compete with local initiatives already in place? And, coming from a country with a cultural disconnect to the material, what can be learnt and brought back from working in a country with traditional ties to it?

In a process revolving around mutual benefit, knowledge exchange and equal working relationship, the project is formed in dialogue between two different cultures and across disciplinary boundaries. The result is a method for how an aid work project can contribute to develop earth building in both contexts, and shows how the intention of a western architect to provide help in a developing country can change with conversation. Conversation between people, cultures and contexts: a conversation with Earth.

Keywords: Earth building, knowledge exchange, collaboration, The Gambia

Thank you Lena & Linnea for doing this journey together

Thank you Aisha for endless help and support in The Gambia

*Thank you Anders, Ann, Axel, Bengt-Ove, Birgitta, Catarina,
Eivor, Henrik, Monica, Monika, Märta, Ulf, Ulrika and Ulrika for
your donations that made the workshop possible*

Author

I started studying Architecture at Chalmers in 2017. Growing up on a farm I've always had an affinity for nature and ecology, and from a background in carpentry I have knowledge of practical construction, mainly with wood. Architecture in regards to sustainability has thus been a prominent part of my studies and personal drive.

My exchange at ETH in Switzerland gave me extended knowledge on sustainable materials, and the ensuing master studies at Chalmers added the social dimension. It is in this personal interest to get involved in architecture work for sustainable development and social change that this thesis takes its starting point.

This project is about earth as a tool for sustainable development. It's about different views on building with it depending on the context, and it's about the process of a western architect finding a way to fit into the context of a developing country; all in a process constantly transforming with dialogue. It's a conversation between different cultures and disciplines, views and opinions, expectations and outcomes, contributions and learnings.

Thank you to everyone whom I've met, interacted and worked with. Without any of you, this conversation would not have been possible.

Thank you!





Salaam Alaikeem

YOUR HOME IN AFRICA

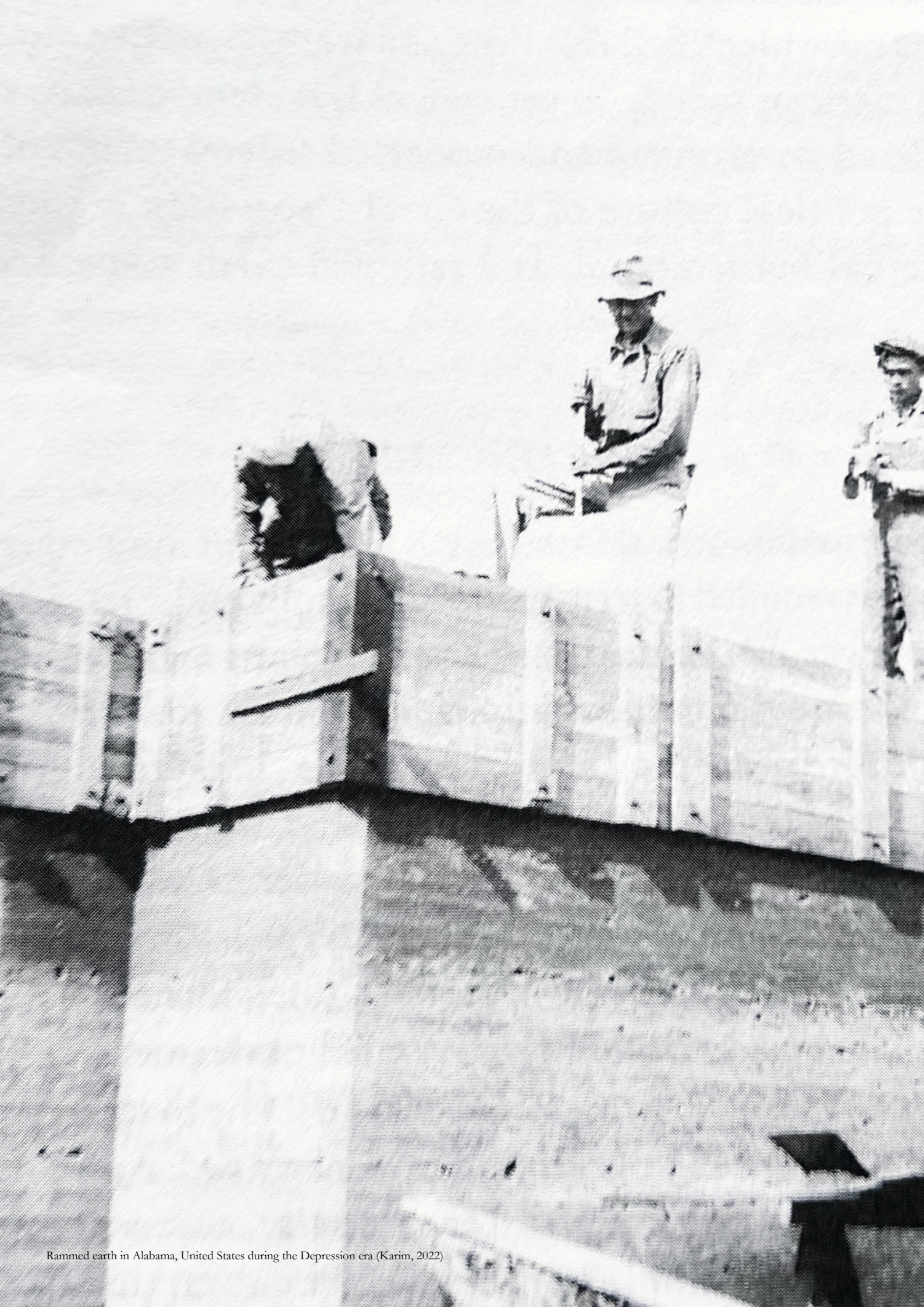
APARTMENT
PEOPLE WITH
THE TRUNKS
OF THEIR
PAST HISTORY
AND CULTURE IS
LIKE A TREE
WITHOUT
ROOTS

HA
CAT

"Conversation with earth"
Impressions of a western architect in
conversation with the Gambian culture

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Introduction

Project background and purpose

Project context

Since spring 2018, the charity organisation Eivor Björkman Gambia Aid has been running a project to build a new school in Ghana Town, a poor fishing community in The Gambia. The Swedish architecture office Detail Group designed a preliminary building concept for the school. A key element in the design proposal was that the school should be built of rammed earth, a sustainable and affordable construction method, thus involving Gothenburg based earth building promoting organisation EarthLab studio in the project. Since the pandemic the project has been on hold, and over those years some of the prerequisites have changed. In order to reinvigorate this project and develop it further, Detail Group and EarthLab propose this as a master's thesis topic, setting the context for this project.

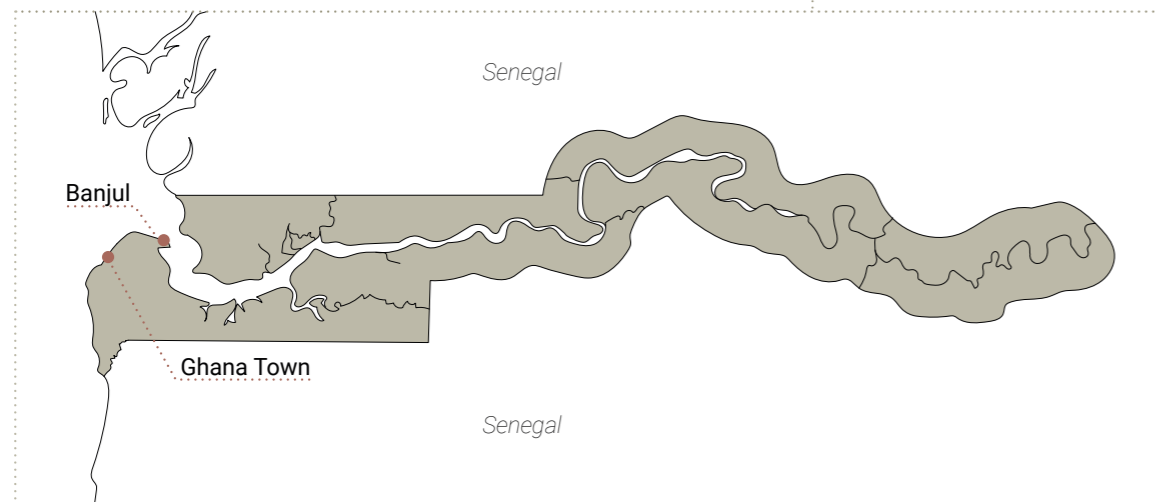
With a recently discovered interest in earth as a material and an inclination toward getting engaged in architectural work for social change, my intention is to explore potentials and challenges for building with earth in The Gambia, and through a process of conversation with the culture, local builders and other actors contribute with the local perspective on earth architecture to the planning of Eivor Björkman Elementary.

In parallel to this project a similar engineering MT project is running, in order to draw learnings from both the architecture and engineering perspective in work in a foreign context.

Involved actors



The Gambia



Location of school plot



Eivor Björkman Elementary
by Detail Group

Background

Earthen materials have been employed by humankind since the Neolithic time. They have been used in constructions in various ways: walls, floors and roof structures (Hamard et. al, 2021). By optimising locally available resources used in construction we created dwellings in harmony with our planet. With the arrival of the industrial revolution in the western world, earth and other traditional materials were discarded as they did not fit the image of modernisation, resulting in a lack of material development and loss of knowledge (Heringer et.al. 2019). Instead, they were replaced by industrialised materials allowing an increased speed of construction, minimisation of human labor as well as enabling standardisations. However, these industrialised materials often require high temperature and toxic processing combined with long transportation chains, causing carbon dioxide emissions and large consumption of non-renewable resources (Ben-Alon, 2019). To reach the goal of the 2015 Paris Agreement and the UN Sustainable Development goals, it is crucial to urgently decarbonise the building and construction sector. To keep relying on conventional industrialised building materials is mostly unsustainable as many of them leave behind a great environmental footprint (UNEP, 2019). Today, with a rising awareness of environmental, economical and social sustainability a changing attitude toward earth architecture can be seen in the industrialised world, as an affordable and sustainable alternative for construction (Vyncke et.al., 2018), but a lack of material knowledge among architects, engineers and builders as well as adaptation of it to industrial processes stands in the way of mainstream commercial use.

”*Earthen architecture is one of the most original and powerful expressions of our ability to create a built environment with readily available resources.*”

– UNESCO World Heritage Convention, n.d.)

The first major attempt to institutionalise and standardise earth architecture was done by french architect François Cointeraux (1740-1830) during the french revolution. Cointeraux, whose career spans revolutionary and post-revolutionary France, dictated his entire career to establishing rammed earth, or pisé, architecture an instrument of social justice and political freedom (Cellar & Richaud, 2005). In 1789, just a few months before the revolution broke out, Cointeraux established the École d'Architecture Rural in Paris, a school for rammed earth architecture and agriculture. The Comité de Salut Public, a provisional government during the Reign of Terror of the French Revolution, appreciated Cointeraux's focus on rural architecture and pisé and picked up earth as a symbol of the poverty-stricken rural France as opposed to the tyranny of its urban elites (Karim, 2022). In his writings, Cointeraux pointed to the technique's classical roots in Europe, highlighting that pisé was introduced to France by the Romans. At the same time, his argument for pisé was more about its symbolic celebration of vernacular aesthetic and political emancipation of the rural poor (Karim, 2022). Thus, while pisé was not entirely unknown to pre-Revolutionary France, Cointeraux's advocacy of the material gave it new meaning (Rozier, n.d.). Cointeraux further argued that pisé was a more appropriate building material than wood, given that scarcity of lumber would not only affect the building industry but also the bakery industry, in turn causing shortage of bread: a key concern of the state as one of the main triggers of the revolution. In addition to help landless classes resist exploitation, the use of pisé would retain and balance the economic and social fabric of France in its wider understanding, expanding the meaning of pisé to encompass overall social revolution of rural peasant life (Garric, 2013).

Cointeraux's idea of pisé and its fostering of political justice was based on four assumptions. The first was that rammed earth architecture would give destitute peasants a sense of dignity. The second was that pisé should be conceived as part of a larger economical system in agricultural

production. The third assumption was the idea of inter-discipline, to combine theory with practice, challenging the epistemological framework of his time and arguing for breaking down disciplinary boundaries. The last assumption was the construction of an autonomous world for the peasantry, using pisé to minimise their dependance on other trades (Baridon et.al., 2016). By combining architecture and agriculture under the term agritecture, he not only trained students in hands-on pisé building but also in agricultural enterprise (Lee, 2007).

Cointeraux's works were published and spread across Europe at the end of the eighteenth century, but it was never adopted widely and only remained an experimental method, popular with small groups of idealists envisioning it as instrument for social change in rural areas (Karim, 2022). At the end of World war one rammed earth attracted interest as a result of the dire shortage of building materials in Europe, and the economic crisis of the Depression in the America provided the background for the

federal government's interest in learning whether pisé was a financially and logistically feasible option for the rural poor. Here, architect and engineer Thomas Hibbing tried to systemise and standardise a method for mass production. However, these efforts were somewhat at odds with the view of the US Department for Agriculture (USDA) and Agricultural Experiment Stations (AES) – government research centres – who's central assumption on rammed earth was that it should be a labor-intensive project in order to deal with the unemployment and surplus of human resources. The studies on pisé conducted by the AES were all conditioned by the socio-political assumption of active participation by the unemployed and their voluntary input of "free" time into building assets. In other words, that unemployed people would be willing to sacrifice their labor if mobilised for a greater good (Karim, 2022). It is in in the context of the Great Depression, Karim argues, that rammed earth developed into its "developmentalist avatar" as an instrument of hope for the underemployed and marginalised in time of crisis (2022).



Workers laying rammed-earth blocks at UNKRA (United Nations Korea Reconstruction Agency) housing in South Korea following the Korean war 1950-1953 (UN Photo Archives)

In the postwar era, 1950s and 60s, earth architecture was an important component in global development discourse. For some, it was seen as a harbinger of an ecologically and socially conscious building industry, whereas developmentalist architects considered it the last resort to the housing problems of the developing countries. The UN's postwar discourse on earth architecture, which might be seen as a continuation of the ideas that emerged during the French Revolution, was geared toward a social technique providing minimal living conditions as well as a collective hope for future prosperity. The idea was self-help as a tactic to use local resources to fight poverty and political totalitarianism (Karim, 2022). However, the UN's efforts in promoting and spreading earth architecture has later been criticised by the architectural historian Felicity D. Scott, suggesting its intent was not to produce an active working class population but rather to keep the poor docile and agreeable by providing the bare minimum (2016). Fathy (1973) propagates for a similar self-help tactic, deeming development without it an impossibility. However, in such efforts cooperation is key, he points out: Without the participation of the architect, the buildings will be ugly, inappropriate and/or expensive. Without the cooperation of the people, the project will be sterile, unloved and untended (1973). Although aimed at different goals, Fathy's careful architectural approach in aiding with the construction of New Gourma in Egypt stands in stark contrast to the method oriented, mass production self-help efforts of the UN.

In American and French counterculture in the 1970s, rammed earth embodied individual empowerment and autonomy as opposed to structures of capitalist exploitation, and began to symbolise radicalised notions of land ownership and the right to build (Maniaque-Benton, 2001). To contrast this, earth architecture was reworked as a cultural sign representing the underdeveloped in development discourse, manifesting the complex image of earth today: an inevitable stage in development toward industrialised society on one hand, but on the other, a way toward an alternative future to which industrial societies would *return* (Karim, 2022).

” *Even a rich country cannot afford to keep wasting resources in its attempt to construct glossy and shiny buildings, a dinosaur from the past.*”

– Diébédo Francis Kéré (Designboom, 2021)

The narrative of earth architecture in development discourse as a temporary response against a specific moment of crisis, and its historic connotations of underdevelopment and rurality has led to the regard of earth as a material unfit for a modern, industrialised society. In industrialised countries, its use in construction has been hindered by a lack of knowledge and universal standards as well as an industry unable and unwilling to adapt (Vyncke et.al., 2018). In developing countries, the use of earth is thus considered as a backward step in the strive for development. However, in the age of development earth architecture has never really had a chance to become a material for the future. It has rather been relegated, as a result of its nature as a locally available, low cost and labor intensive material, to rural contexts, experimental self-builders and temporary, minimal housing as a response to crisis. In these contexts the cooperation between architects and people that Fathy (1973) promotes has, to a large extent, been missing, naturally hindering earth architecture to develop and adapt to construction in the age of development.

It is in cooperation that this thesis work takes its point of departure. The aim is, through collaboration, to identify and develop strategies for how an aid work project in The Gambia can contribute to development of earth building there, how a western architect can fit into the Gambian context, and how the process of working there can be one that's centered around equal benefit and knowledge exchange.

” *Ironically, most public housing in the world today is done without the cooperation of either the architect or the people. It is a bureaucratic decision built by contractors, and, whether horizontal or vertical, it almost immediately becomes a slum.*

It is perhaps the final irony of our age, as Dr. Fathy reminds us, that it costs more to produce this form of ugliness and that we will be driven toward better, more beautiful housing simply because we cannot afford any other kind.'

– William R. Polk (Architecture for the poor, 1973)

Method

Theory

While carried out with good intent, externally funded projects like this one undoubtedly raises questions about the legitimacy of international promotion of a certain way of living, educating and building in a developing country. Is promotion of earth as a building material and construction method suddenly deemed as "good" for sustainable development appropriate, even though industrialised countries have refrained from it for centuries? How can the architectural aspect of a project like this be carried out in an adequate way that will render mutual benefits and foster an equal knowledge exchange? And is there a down side to externally initiated and funded aid projects, with the receiver possibly ending up in a position of dependency rather than in possession of tools to initiate and carry out their own? The criticism of the UN's self-help tactics in the middle of the 20th century might attest to this. At the same time, the absence of architect involvement and people collaboration in those processes suggests that other outcomes might be possible.

Earth building's recent revival as a way toward a sustainable building industry comes with challenges of lack of knowledge and adaptation to industrialised building processes, and notions of it being a material unfit for modern society due to connotations to temporary low-cost and rural housing. In all of those instances, architect involvement in the process and interest in the material, or lack thereof, plays a large role, however cannot solely be the solution: builders, engineers and other representatives from the building process as well as, most importantly, people, the final users and inhabitants of the built environment, also have to be involved. If earth architecture truly is to be the alternative future that Karim proposes, a comprehensive and holistic architectural approach is necessary.

The advocacy of interdisciplinary and practical learning by Cointeraux and the cooperation between architect and people as promoted by Fathy lay the foundation for the work carried out within this thesis.

Method

The methodology follows a gradually upscaling process, building and expanding on knowledge acquired in the previous steps. The aim of this work is not to learn a building method in a foreign context that may or may not be used ever again; it will be about finding synergy in knowledge from two different contexts that might lead to an improvement of both. Equal and mutual knowledge exchange through interdisciplinary interactions and practical collaboration is central to the process in which collaborative workshops will be a recurring format.

Acquiring knowledge and experience with the material leading up the collaborative processes during the field studies is of great importance in order to foster knowledge exchange. Therefore, the first phase starts with theoretical and practical hands-on learning about the material and earth construction methods. An understanding for mixing and production procedures will be developed together with the engineering students following the same topic, and concludes in an upscaled building process in an educational rammed earth workshop at Chalmers.

During the field studies interactions, interviews and participatory actions will inform the direction of the project as to potential roles that a western architect could fill in Gambian earth building industry today. It will identify potential for mutual benefits and opportunities for knowledge exchange, and in that process develop a method for how collaboration and conversation between a western architect and Gambian earth builders can generate a platform for knowledge exchange. The field studies will conclude in an implementation of this method, in the form of a collaborative design and build workshop.

The learnings from that process and what it brings to the different involved actors will be summarised, and the local perspective on earth building in The Gambia will be conveyed to the planning of Eivor Björkman Elementary in a re-imagined design concept based on the current state of the Gambian earth building industry.

Delimitations

This thesis will:

Explore how collaboration with local earth building actors can generate a platform for mutual benefit and knowledge exchange

Provide the local perspective on earth building in the Gambia and show how that can affect the design concept of a school building of earth

Identify what type of role a western architect can fill in the existing earth building industry of The Gambia

Develop practical and theoretical knowledge about earth building and its challenges

Explore what learnings from working with earth in The Gambia can help develop earth building in Sweden

This thesis won't:

Design a school building in The Gambia

Explore complementary materials and building methods to earth in The Gambia

Make detailed structural or economical analyses of earth building

Go into or evaluate the use of stabilisers in earth building

Purpose and objective

Purpose

In light of a large predicted imminent global development rate the need for low carbon, affordable and abundantly available building materials is imminent, and earth can be one of the solutions. For this, spread of knowledge and designer involvement in the use of the material is necessary to adapt it to modern construction processes and elevate its profile from a material branded as a temporary or inevitable answer in lack of other options, to a building material for a sustainable and better future.

One of the goals of the project Eivor Björkman Elementary is to promote earth building in the context of The Gambia, a developing country. In order to do this in appropriate and adequate ways, a deepened understanding of the cultural context, the current state of the building industry and prospects for earth in its future are essential.

What type of role can an international architect fill in the context of The Gambian earth building industry? How can an externally funded school project like this support and elevate rather than compete with local initiatives already in place? And, coming from a country with a cultural disconnect to earth architecture, what can be learnt from working in a country with traditional ties to it? There are both similar and different types of challenges for the use of earth in construction in developed and developing countries, and thus opportunity to learn from each other's contexts to overcome them.

The main purpose is to explore how a project in The Gambia driven by an international actor can provide a platform for mutual benefit and knowledge exchange in an equal working relationship, and how conversation between a western architect and The Gambian culture can change the perception of how we can contribute with help. The learnings will generate new opportunities for use of earth in Sweden as well as in The Gambia, and provide the Gambian perspective on earth building to Eivor Björkman Elementary, in order to initiate the same type of conversation between cultures and views in the planning of this school.

Aim

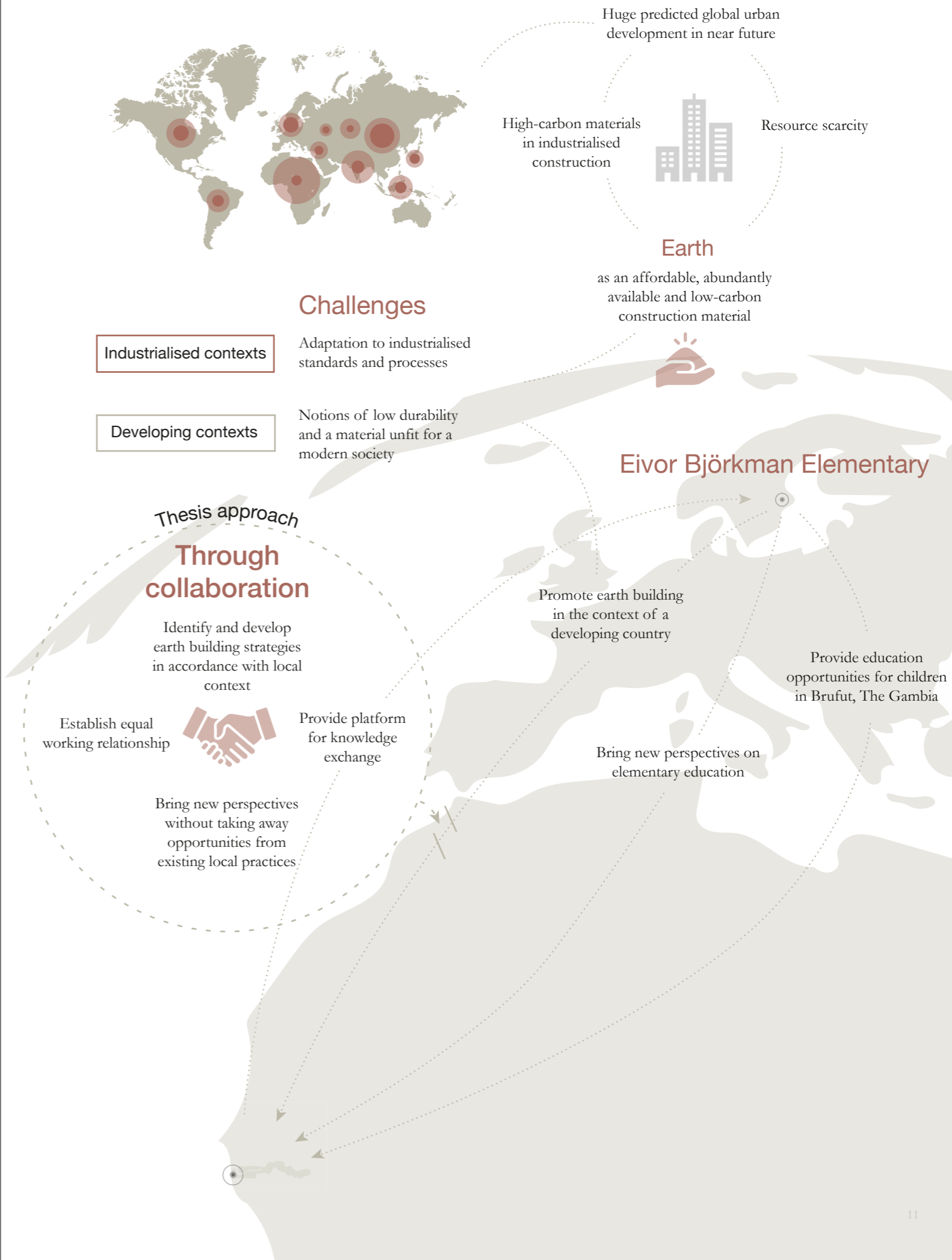
Identifying and understanding the nuances of the Gambian perspective on earth building, finding what perspectives an international architect from a western context can bring to the existing Gambian earth building industry, and how a collaboratory design process can be carried out with mutually beneficial knowledge exchange in an equal working relationship are the main aims of this project.

Practical knowledge and experience gained while working in a context with a cultural and traditional connection to earth building that could contribute to the lack of knowledge about the material in a country like Sweden will be brought back. At the same time, new perspectives on earth building and opportunities for local earth building actors in The Gambia will be developed together with them to create lasting benefits extending beyond the project itself.

With point of departure in hands on learning and interdisciplinary collaboration, this thesis focuses on the earth building promoting aspect of Eivor Björkman Elementary. The focal point of the process is to develop an understanding for building with earth in The Gambia in ways that won't be disregarded as neither retrograde nor unattainable. This local perspective will contribute to the planning of the school, to help develop it into a project that is well anchored in its context and can serve as an inspiration and exemplary model for future earth projects in The Gambia.

The process runs in parallel with a similar engineering project, drawing learnings from the perspective of architecture and engineering, in addition to that of local actors.

Sustainable development



Research question

How can a Swedish initiated earth school project in The Gambia provide a platform for knowledge exchange that will contribute to developing earth building in both contexts?

Sub-questions:

How can a collaborative design process based on mutually beneficial knowledge exchange and equal working relationship influence the design concept of a school building in The Gambia?

What type of role can a western architect fill in the context of The Gambian earth building industry?

How can an internationally driven and funded school project support and promote earth building in The Gambia without taking away opportunities for existing local practices?

What learnings from working in a country with traditional ties to earth building can be brought back to develop earth building in Sweden?





Building with earth

History and today

Building with earth

Historically, raw earth has been used for residential, religious, commercial and monumental structures. It has been the most prevalent building material world-wide. Architectural excavations have revealed earth buildings in Russian Turkestan dating back to 8000 to 6000 BC (Minke, 2006). The famous Great Wall of China (770 B.C.) is in large parts a rammed earth structure, that only later got covered with stones and bricks (Anysz, Narloch 2019). In ancient times raw earth was widely used in Mesopotamia and Egypt, as well as later on in Europe, Africa and Middle East. Furthermore, earth buildings are found in nearly all pre-Columbian cultures in Mexico, Central- and South America such as the Indus, Toltecs, Aztecs and in the Andes by Mochica (Mwakyusa, 2006).

One of the great pioneers in promoting a modernisation of earth constructions in the early 20th century was Egyptian architect Hassan Fathy (Dethier, 2020a). As one of the prefigures promoting affordable housing, he devoted himself to rural improvement in developing countries, working to intertwine nature, traditions and spirituality with modern aesthetics in his project. The outcome was a more locally centred form of modernity that often got constructed out of earth (Zaineldine, 2021). His project New Gournia from 1945, built with mud bricks together with the villagers, still holds a significant position serving as inspiration to architects all over the world.

Revival in 2000s

Since the late 1900s, earth has experienced a revival as a sustainable and affordable construction method. There are several internationally renowned contemporary architects that have supported this revival and through their work demonstrated the possibility to use it in modern construction. The use of rammed earth became popular in America with architects like Rick Joy integrating the technique in luxury villas. Francis Kéré (Berlin/Burkina Faso) is another key actor with his innovative rural schools and medicine centres, being awarded the prestigious Aga Khan reward for Architecture in 2004 as well as the Pritzker Prize in 2022 for his work with sustainable development and community involvement (Archdaily, n.d.). Nigeria based Mariam

Kamara has constructed several projects out of raw earth, and the same goes for Wang Shu in China whose most recent project is the multi-purpose urban estate at the gates of Paris. This was developed together with CRAterre and Anna Heringer, a German architect also recognised with the Aga Khan Award in 2007 for her efforts to strengthen local building skills, cultures and foster ecological balance (Heringer, n.d.).

Earth in construction today

Building with earth in industrialised countries is and has remained an experimental and alternative method throughout the age of development, although it is clearly on the rise again. Due to the loss of cultural ties to earth construction as a result of industrialisation, the re-discovery of earth in industrialised countries today represents a "new" and intriguing way to build with natural materials, with a large part of its appeal to architects and designers lying in its raw authenticity and unexplored potential (Boltshauser, 2019). There is however a general lack of knowledge of earth in construction and adaptation of it to the conventional construction methods of today. The development of industrialised processes for building with earth to reduce labor costs and allow for standardisation is essential if earth is to be a viable alternative implementable on a large scale in industrialised contexts (Heringer, n.d.).

In developing parts of the world, where labor is comparatively cheap and the material is a larger part of the total cost of building, manual or semi-automated earth building techniques might be implemented competitively and with success. Construction methods need to be improved, but the need for adaptation to existing industrialised processes is lesser, and the challenge is to a larger extent about social acceptance of earth as a material for the future. Due to associations with low cost, low durability and traditional rural houses, social reluctance to earth building can be encountered. As social acceptance depends a great deal on how a material is presented to the population, organisations, political decision makers and designers have an important part to play in this respect (CRA Terre, 1991).



New Gournia Village by Hassan Fathy, 1945 (Archdaily, n.d.)



Gando Primary School by Francis Kéré, 2001 (Archdaily, n.d.)

Earth building methods

Rammed earth

The earth is poured within a temporary formwork and compacted by means of a rammer, layer by layer, forming a monolithic wall with a horizontal pattern reminiscing of the construction process after the formwork is removed.



Rammed earth wall in Casa Ajijic, by Tatiana Bilbao 2010 (Archdaily, n.d.)

Cob

The earth is shaped into balls which are piled on top of one another and lightly packed manually to create shaped monolithic walls. The earth used is often improved by straw or other fibres, and cob balls can be used in combination with timber framework or structure.



Adobe blocks laid to dry in the sun (Timothy O'Keefe, n.d.)

Adobe

The earth, in a formable state often mixed with straw or other fibres for increased structural capacity, is moulded in a brick form and dried in the sun.



Compressed earth blocks

Compressed earth blocks

Can be seen as an improvement of the adobe technique developed in the 1950s to compress slightly moistened earth in a steel press, manual or automatic. Compared to the hand moulded block it is very regular in size and shape, and much denser, giving it better resistance to compressive stresses and water (CRATerre, 1991).

Other methods

In the buildings like the Burkina Institute of Technology and Gando secondary school, Francis Kéré used poured clay, a mix of clay, earth and cement, to cast the walls of the structure in-situ (Archdaily, n.d.).

Mario Cucinella used local raw clay mixed with rice fibre in the TECLA houses, a 3-D printed prototype for a house that is completely disposable (Archdaily, n.d.).



Burkina Institute of Technology (Archdaily, n.d.)



Galeria 2 Hijas in California, built out of cob in 2021 by Cla Clá (n.d.)



TECLA Huses prototype by Mario Cucinella (Iago Corazza, n.d.)

Sustainable development

Sustainable development, widely recognised as the major challenge of our time and defined by the UN Sustainable Development Agenda as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN.org). To eradicate poverty and build an inclusive, sustainable and resilient future for people and planet, it is crucial to harmonise economic growth, social inclusion and environmental protection as climate change is already impacting public health, food and water security and peace. Climate action to reduce greenhouse gas emissions and build climate resilience is a key driver of sustainable development (UN.org).

Human caused global warming, social inequality and poverty are the focal points of the UN Sustainable development Agenda. In 2015, the 17 sustainable development goals were adopted by all UN-member states, setting out a 15-year plan for achievement of those goals as part of the 2030 Agenda. The 17 goals, containing 169 specific

targets, include challenges such as climate change, economic inequality, sustainable consumption, peace and justice, among others. The goals apply to all countries, rich and poor, although each country is expected to pursue the different targets in accordance with its own priorities. In 2019, world leaders at the SDG Summit called for 2020-2030 as a decade of action and delivery for sustainable development, if the goals are to be reached by the target of 2030 (UN.org).

To limit global warming to 1.5 Celsius above pre-industrial levels as set out by the Paris agreement in 2015, global GHG (greenhouse gas) emissions will need to peak before 2025, decline by 43% by 2030 and net zero by 2050 (UN.org). In other words, the need to reduce emissions is here and now, and every year we fail to act, the level of difficulty and cost to reduce emissions goes up. The urgency is there, the incentives are there, but things are progressing too slowly for the goals to be reached in time, and drastic change is needed (Emissions Gap Report 2019).



The 17 sustainable development goals (UN, 2023)

Sustainability in the construction sector

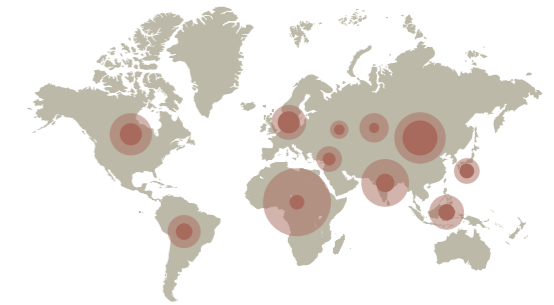
The built environment is a big contributor to human made GHG emissions, generating 40% of the annual global CO2 emissions. Of those total emissions, the operational phase of the buildings are responsible for 27% annually, while materials and construction, embodied carbon, are responsible for 13%. (Architecture 2030). These emissions will continue to increase with the current wave of the largest urban growth in human history, with the global building floor area expected to double by 2060: the equivalent of building one New York city every month for the next 40 years. It is also clear that the vast majority of new buildings will be built in developing countries. In Africa for example, the current floor area is expected to more than triple in the same time span, giving the continent the highest predicted development rate globally (architecture 2030).

Operational carbon emissions have the chance to be reduced over time to net zero with the use of renewable energy, passive ventilation and temperature regulating systems etc., whereas the embodied carbon is locked in place as soon as the building is built. It is critical to get a handle on embodied carbon now if hope of achieving zero emissions by 2040 is to be retained (architecture 2030).

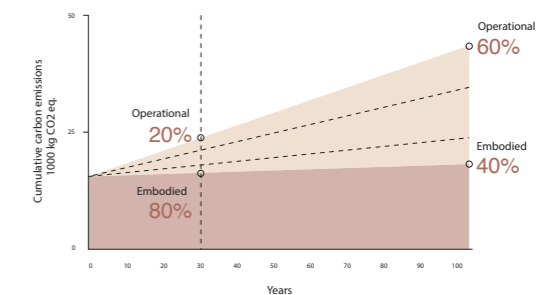
Opportunity for design and material

When examining the distribution of mass in a medium high-rise building (~10 stories), a building typology common in urban densification, 75% of the total mass lies in its structure. Of those 75%, 25% are in the walls and 41% in the floors. The structure is in large part there to support itself, and spanning of space constitutes a considerable amount of the entire mass, and in turn the embodied carbon, of the building (Block, 2021).

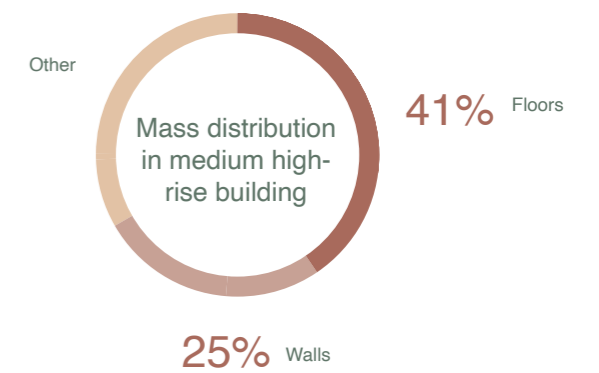
Through reduction of the high-impact materials and structure optimisation and specification of low carbon materials, there is incredible opportunity for embodied carbon reduction through design and material selection (architecture 2030).



Global floor area expected to double by 2060 (Architecture 2030)



Total carbon emissions of global new construction, showing the critical role embodied carbon plays (Architecture 2030).



Mass distribution in medium high-rise building (Block, 2021).

Sustainability of earth

With a rising awareness of sustainability in the construction sector as well as rise of cost and demand of construction materials, earth construction is experiencing a revival and is now more relevant in modern construction than ever before. The benefits of earth as a low-processed, locally available and indoor climate regulative material as promoted throughout history are still relevant today, and in light of the climate change crisis and strive for sustainable development earth has the chance to play a key part in the drastic change needed in the construction sector. According to the 2019 Global Status Report for Buildings and Construction by the UN Environment Programme, a key action to increase sustainability in the construction industry is to introduce information on low-carbon materials, such as earth (UNEP, 2019).

Beyond reduction of carbon emissions, development of earth construction align with the UN-goals for sustainable development, with focus on number eight, nine, eleven and twelve.

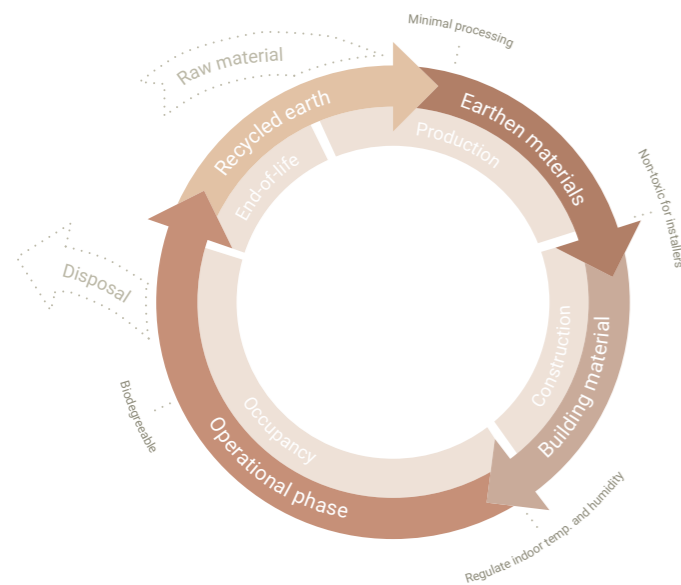


Decent work and economic growth: Through local material sourcing and production for construction, new employment opportunities and domestic trade will empower the local economy and make it less dependent on import and global market trends.

Industry, innovation and infrastructure: The UN deems industrialisation as crucial to sustained growth and reduction of economic inequalities (2020). In earth construction, there is need and opportunity for industrialisation and innovation to make it an accessible option to all people.

Sustainable cities and communities: The UN identifies inequality and the high levels of urban energy consumption as some of the most pressing challenges that cities face today (2020). There is need for more accessible, cheaper and less energy demanding construction, needs that earth construction could help fulfil.

Responsible consumption and production: Our reliance on natural resources has risen with over 65% over the past 20 years, with increased consumption, production and waste as the main drivers (UN, 2020). Earth, as a recyclable material that can make use of excavation waste from the construction sites, can help transform the construction sector to a more circular one.



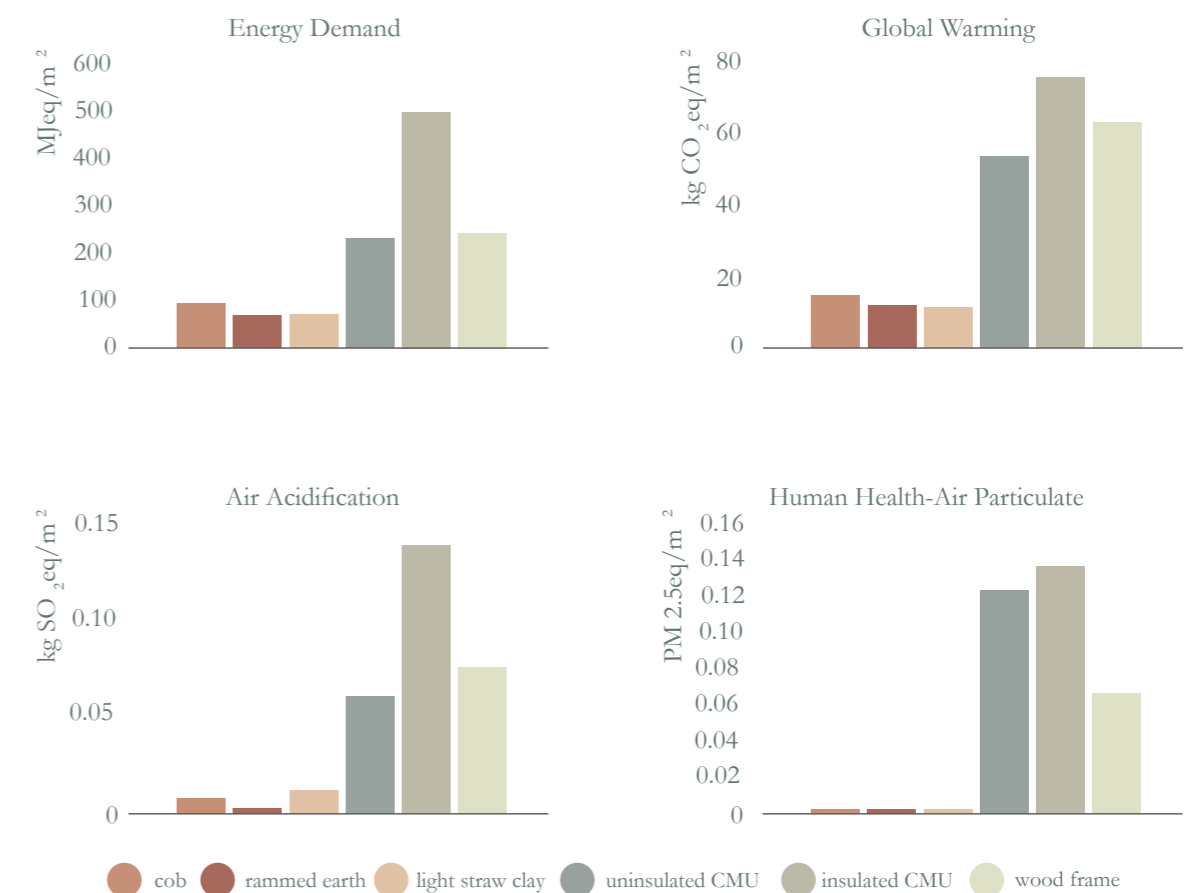
Life cycle of earth as a cradle-to-cradle circular building material (Ben-Alon et.al., 2019)

Life Cycle Assessment

To evaluate building materials in terms of environmental impact, LCA (Life Cycle Assessment) is a tool that can be used. It is defined as systematic analysis of the potential environmental impacts of products or services during their entire life cycle (Sphera, 2020). LCAs on earthen materials for construction have not yet been studied thoroughly enough to make decisive conclusions, as time is needed to evaluate them in modern construction and environmental impact will depend on a lot of factors during the operational phase of the building. It is widely argued however, that they have a lesser environmental impact than conventional materials thanks to local availability, non- to low procurement procedures and circular life cycle (Ben-Alon et.al. 2019).

An LCA comparing different earthen construction techniques to conventional materials was published

in 2019 by Ben-Alon et.al. This LCA does not take the use and end-of-life phase into consideration, but only the impact from cradle to construction site. It includes embodied energy demand, global climate warming impact, air acidification and human health (HH) air pollution. In the study, 1 square metre of six different wall materials were investigated in the context of a warm-hot climate in the US: cob, rammed earth, light straw clay, timber frame, and insulated as well as uninsulated concrete blocks. The results show that walls made of earthen materials have significantly lower environmental impact than conventional wall systems (Ben-Alon et.al. 2019). Several earthen materials have also been accepted in BREEAM (Building Research Establishment Environmental Assessment Method), putting the embodied energy of the material into context with other wall building systems. The earthen materials receive high grades, with for example rammed earth rated as an A+ material (Rammed Earth Consulting, n.d.).



Environmental embodied impacts comparison among the wall systems: cob, rammed earth, light straw clay, uninsulated Concrete Masonry Unit (CMU) blocks, insulated CMU and wood frame (Ben-Alon et.al. 2019).

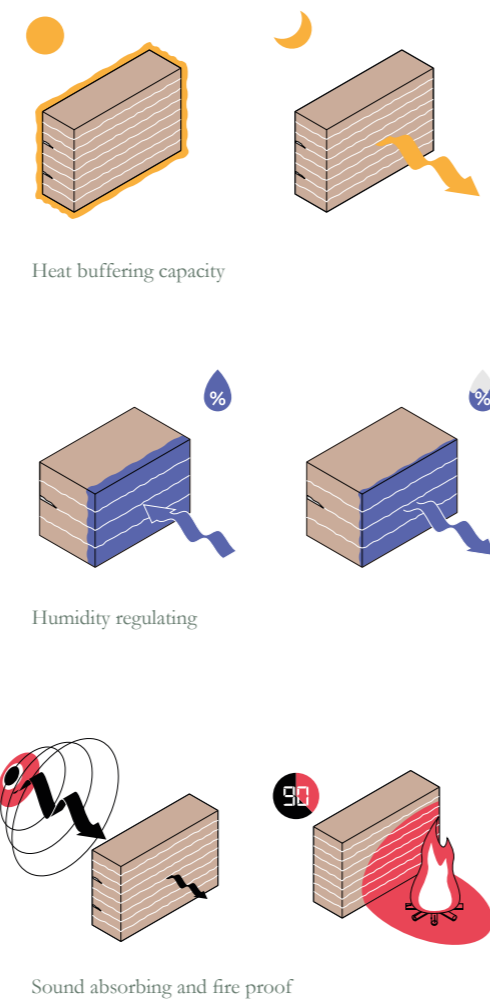
Technical properties

Physical properties

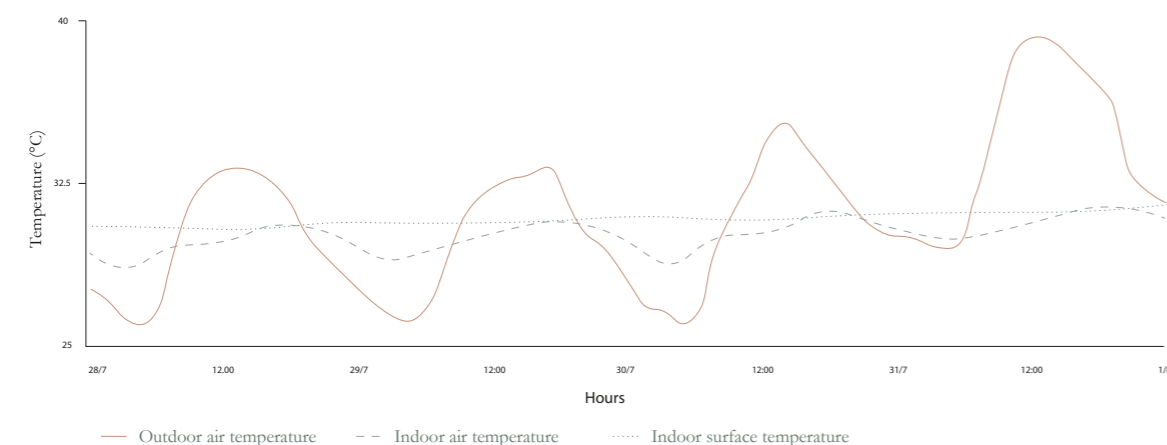
Having high thermal mass, earth walls can store a lot of heat to act as a "heat buffer", flattening the highs and lows in daily temperature extremes. Indoor temperature is cooler during the day and the stored heat is slowly released as warmth during the night (Erden, 2022). This is particularly relevant in temperate climates with a large thermal oscillation between day and night, stabilising and balancing the temperature to ensure a comfortable indoor climate (Giuffrida et.al. 2021).

Earth is also highly hygroscopic, i.e. it allows moisture to travel through its permeable microstructure, giving earthen walls their humidity regulating properties. When humidity is high indoors, the wall soaks up excess moisture to roughly 55%, and releases this moisture back into the room when the humidity is low (Erden, 2022). This is optimal for thermal comfort and respiratory health – if the relative humidity is too low (below 40) or too high (above 60) it can cause respiratory problems (Fabbri et.al. 2022). Measurements made in a newly built earthen house in Germany showed that during a period of eight years the relative humidity was almost constantly 50%. The building was able to reduce humidity in the summer and elevate it in the winter (Minke, 2006).

In addition to heat storing and humidity regulating, earth also has excellent sound absorbing and fire protection properties.



Figures retrieved from Erden, 2022



Thermal analysis performed on an uninsulated rammed earth building in Mediterranean climate during five days of the hottest summer week 2019. Highs and lows of indoor air temperature are flattened, and indoor surface temperature remains close to constant (Giuffrida et. al. 2021)

Structural properties

The structural ability of earthen materials is highly discussed and viewed upon differently. In comparison to industrially processed materials, there is a general lack of knowledge and technical data on performance of earthen structures. In some countries standards for earth construction have been established, whereas in other countries, guidelines through normative documents, which can be seen as an initial stage toward development of a standard, have been published. Countries with officially recognised standards include, among others: Germany, France, Brazil, Colombia, US, New Zealand, Kenya, Zimbabwe, Turkey and India (Schroeder, 2014). In 2018 the African Organisation for Standardisation (ARSO) published the African Standard for compressed stabilised earth blocks.

Standards and guidelines cover production, testing, engineering and design of earthen structures aimed at both designers, builders and estate evaluators (Rammed Earth Consulting, n.d.). The function of a standard is primarily to serve economic and social aims, to facilitate the exchange of goods and services in a way that protects the consumer (safety, product quality, etc.) and ensures a good quality of life (health, hygiene, environment, etc.) (Schroeder, 2014). The main issue with adaptability and acceptance of earth in modern construction is the variances in structural properties that come as a result of low-tech production methods and the high dependence on the raw material. The development of standardised

methods for earth building and production is of importance, especially in industrialised contexts where prefabrication is already common practice and need for consistent material performance to meet standards is a fact (Heringer et.al. 2019).

Due to its unprocessed and non-hardened nature, earth is essentially water soluble and therefore susceptible to excessive water exposure. Rain running along an earthen facade will wash out particles over time, and the higher the speed of the running water the higher the destructive effect. Similarly, falling water penetrating from the top, through shrinkage cracks or by flooding at the bottom can affect and in worst case ruin the stability of the entire structure. To make the structure more water resistant, the use of earth is often done in combination with stabilisers, most commonly cement. By adding from a few to up to 10% cement, the strength can be increased slightly and make the earth more resistant. However, this relatively small amount will result in higher embodied carbon and the reduction of two of earth's most valuable characteristics – its full recyclability and moisture buffering properties (Erden, 2022).

There are examples showing that stabilisers might not be needed and that protection from weathering agents largely can be solved by taking proper architectural measures in the design of the building, again pointing to the responsibility and opportunity designers have in developing earth construction. As Erden argues, "No cement stabilisation is needed with good design" (2022).

Compressive strength and density

	Rammed earth Unstabilised	CSEB Compressed stabilised earth blocks	Fired Clay bricks	Concrete
Density	2000 kg/m ³	1700 - 2200 kg/m ³	1400 - 2400 kg/m ³	2350 kg/m ³
Compressive Strength	2 - 4 N/mm ²	2 - 8 N/mm ²	4-7 N/mm ²	17 - 30 N/mm ²

Technical properties of rammed earth and compressed stabilised earth blocks in comparison to fired bricks and concrete. Table adapted from E.A.Adam (2001), Erden (2022), ARSO (2018) and Minke (2009)

Earth for sustainable development

Earth has a definite role to play in sustainable development as a low-carbon, inexpensive and locally available construction material. It is a sustainable alternative to industrialised materials, providing both low embodied carbon and potential for reduced energy consumption during the operational phase of the building. But the potential of earth as a tool for sustainable development extends beyond calculable emission reductions and cost savings in buildings.

In development today, aspirations and strive towards modernity often lead to traditional materials and methods being abandoned in favour of expensive imported products. The result of this is exported economic benefit and introduction of buildings, forms and materials alien to the cultural context (Finch, 2006). In the METI School in Rudrapur, Bangladesh, Anna Heringer and Eike Roswag show that alternative development is possible. By utilising and improving existing building techniques and local potential, they demonstrate how re-thinking earth building today can contribute to strengthen regional identity, increase quality of life and inspire sustainable development (Archello, n.d.).

The METI School

Rudrapur is located in the north of Bangladesh, the most densely populated country on earth. Poverty and lack of infrastructure drive migration from the countryside into the cities, and as a part of an attempt to follow new paths in its development program, the local NGO Dipshikha introduced a special school concept to instil self-confidence and independence in the children, with the aim to strengthen their sense of identity. The idea of it, METI (Modern Education and Training Institute), is learning with joy in a process where teachers help children to develop and use their individual potential in a responsible and creative way. In terms of materials, techniques and design, the building reflect these ideas (Heringer, n.d.).

The project's main strategy is communication and development of knowledge and skills within the local community to make the best possible use of

available resources. Historic building techniques are developed and improved and the skills passed on to local tradesmen, and in that process the image of those old building techniques are transformed (Heringer, n.d.).

Structure

The school is built using the local and traditional materials clay and bamboo. It has a foundation of locally fired clay blocks, and the ground floor is raised with earth and straw in a technique similar to cob: a 70 cm high wall layer is left to dry for two days, then trimmed off with a sharp spade before repeating the process. The ceiling and first floor are built with bamboo: three layers of bamboo sticks with the middle rotated perpendicular to the other two, bamboo planks on top of that and an earthen mixture as floor surface - a principle similar to European timber frame constructions. The walls and roof of the second floor constitutes a frame structure with four layers of joined bamboo as columns and vertical and diagonal poles fixed with steel pins and rope, a modified form of traditional lashing (Archello, n.d.).

Social impact

The result is an inventive architecture in which traditional and local methods are developed and improved in a way that is replicable by the involved local craftsmen in the future. As the only two-story building in the area, the building serves as an example of how local materials and methods can be used to improve the quality of living in rural areas and develop new and refreshing regional identity that maintains a strong cultural and contextual connection (Finch, 2006).

The project received the Aga Khan Award for Architecture in 2007, and as the jury concluded, the design might not be replicable in other parts of the world, but the approach, to allow new design solutions to develop from an in-depth knowledge of the local context, provides a hopeful model for sustainable building globally (Finch, 2006).



Classroom on ground floor, METI School (Archello, n.d.)



METI School in Rudrapur, Bangladesh (Archdaily, n.d.)



Material properties

Knowledge about the material

Soil

Earthen construction techniques are heavily dependent on the raw material – regardless of building technique, the construction will only be as good as the earth used. To understand earthen structures and construction methods, it is essential to have knowledge about the basic ingredient: soil.

Soil can be described as a piece of the earth's top layer, varying greatly in thickness from a few centimetres to numerous metres. It can be seen as a stage in a long process of deterioration, in which rock is transformed into smaller components through erosion. The small minerals migrate downward with the rain and upward to the surface through evaporation. This continuous vertical movement creates distinct layers in the sections of the earth; the so-called horizons (Schildkamp, 2009).

The top soil, agricultural soil and hummus, contains a lot of organic matter and should not be used for construction. The layer beneath, the mineral soil, is the soil suitable for construction. It contains a mix of the different aggregate sizes: gravel, sand, silt and clay. Depending on geographical location, the thickness and composition of the intermediate mineral soil layer will vary, which in turn gives a particular soil its specific properties.



Suitable soil for construction is found in between the top soil and bedrock (Schildkamp, 2009)

The different aggregate sizes:

Gravel: Smaller grains of rock material, with a size ranging from 2 to 20mm.

Sand: Sized between 0,075 and 2 mm, sand has an open and permeable structure. When compacted, sand particles create a dense soil matrix, but will not hold together by itself.

Silt: More or less like sand but with smaller size of particles. As pulverised "rock flour" it fills the voids between the larger grains and increases the internal friction of the soil.

Clay: The glue binding the other aggregates together, giving the material its strength. The amount of clay needs to be handled with precaution: too little clay will result in difficulties for the soil to hold itself together, whereas too much can cause it to shrink and crack during the drying process.

For most modern construction purposes, the ideal soil consists of approximately 15% gravel, 50% sand, 15% silt and 20% clay. However, the exact numbers will vary depending on construction technique, moisture content and soil type (Schildkamp, 2009).

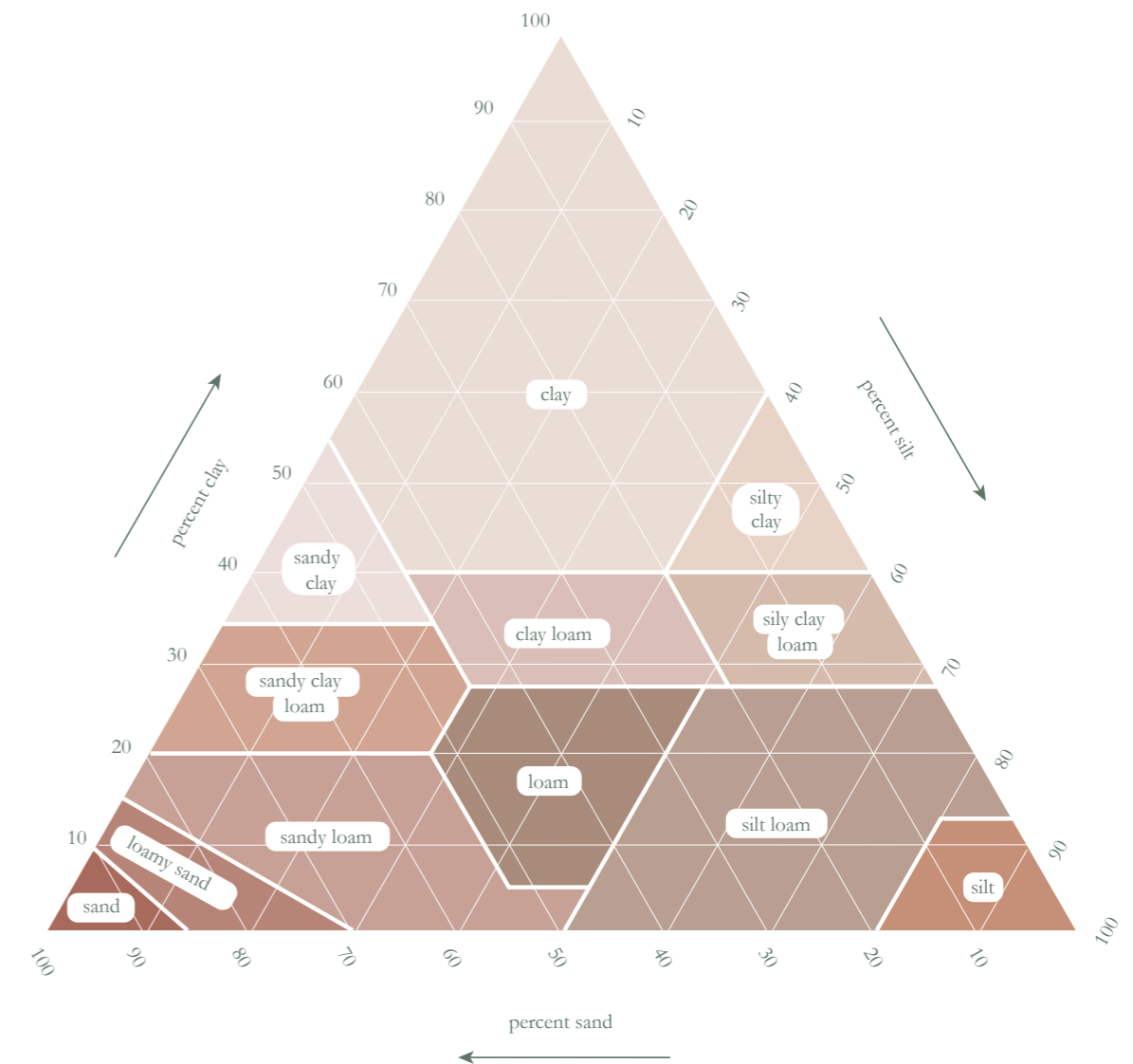
There is a huge variety of soil compositions, soil structures and soil textures, generating many different soil types in which the predominant grain size mostly renders its specific attributes. The number of different types are represented in the "soil triangle" below (Harrison, Robert, n.d.). These can further be divided based on their properties of chemical and physical nature which are plenty but not necessary to have extensive knowledge of for the purpose of earth construction. For that, it is sufficient to have a clear understanding of four fundamental soil properties:

Texture: Grain particle size distribution

Compressibility: The density to which the soil can be compacted

Plasticity: The possibility for deformation without elastic failure

Cohesion: The capacity of the soil grains to remain together under tensile stress (Schildkamp, 2009).



The soil triangle representing 12 different soil types with different characteristics, depending on the composition and particle distribution (Harrison, Robert, n.d.)

Soil testing methods

To test the soil for these basic properties and determine if it is suitable for construction purposes, geotechnical identification tests are often required. However, Schildkamp argues that a combination of simple field tests and experience can be just as sufficient for soil identification purposes (2009). Hands-on knowledge and intuitive feel for the material based on experience is necessary to have the ability to recognise suitable soils, necessary additives and moisture content levels.

Schildkamp lays out a number of simple field testing methods, some of which are described in this section. The main factors deciding if the soil can be used for construction is clay content, aggregate sizes, moisture content and organic material content (Schildkamp, 2009).



Touch test

After removing the largest grains and other unwanted ingredients, now also remove as much gravel as you can. Crumble the soil between the tips of the fingers and the palm of the hand. If it feels very sharp and gritty, it means that there is a lot of sand or silt. If it is smooth and powdery, like white flour or talcum powder, there are a lot of fines present.



Visual test

The soil is examined with the naked eye to estimate the relative proportions of the coarse particles and the fines. The variety in grain sizes, especially gravels and sand, can easily be seen. Stones and large gravel, sticks, leaves and other foreign matter can be removed.

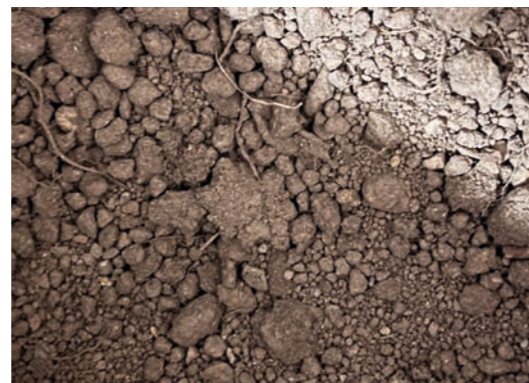


Sandy and silty soil – there is an absence of larger aggregates and the fine particles are dry and rough to the touch



Smell test

Immediately after taking the sample, the smell test can reveal organic content. A few drops of water can be added to enhance the odour of the sample. If the soil smells damp and musty or even rotten, it contains a lot of organic matter making it unsuitable for construction and further testing.



Organic material – this soil has a distinct organic smell as opposed to the metallic smell of mineral soil



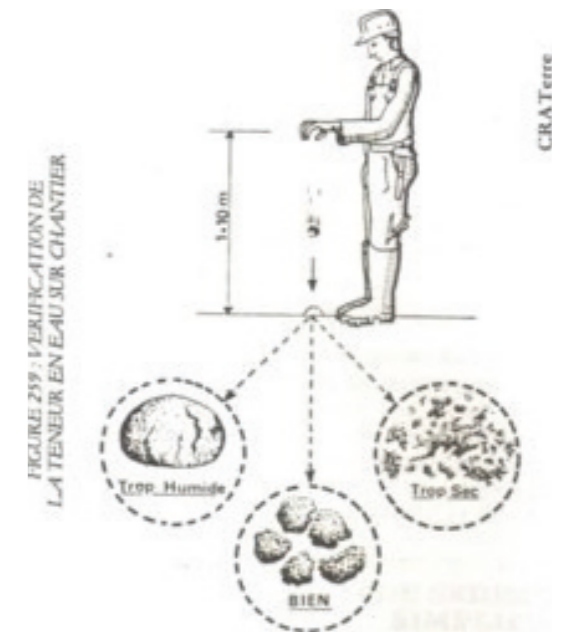
Too much clay or too wet

Suitable for use

Too much sand or too dry

Drop test

This test is done find the optimum moisture content of the mixture just before using it. A hand of soil is wet just enough to make a cohesive ball, which does not stick to the fingers. When dropped from waist height onto a hard surface, the ball should break into 4 to 6 bigger pieces. This indicates a continuous, well-graded soil with good moisture content for construction. If the ball stays in one piece it is too wet. If it disintegrates it is too dry or contains too much sand.

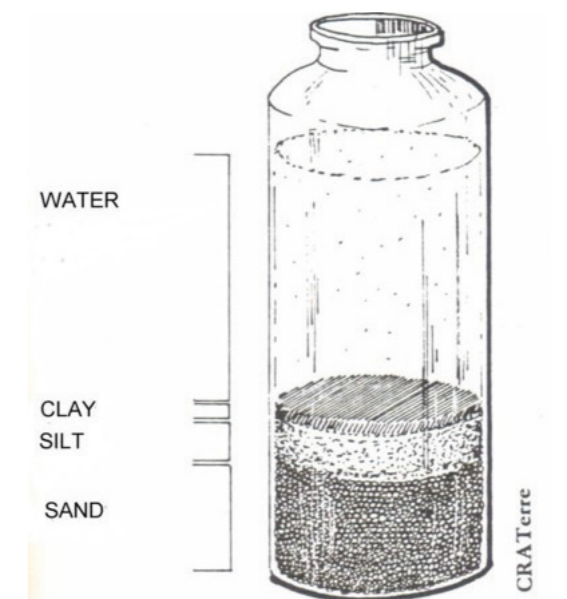


Drop test (CRATerre, n.d.)



Jar test

A clear jar or bottle is filled with one quarter to one third with soil, then filled to the top with clean water. After shaking it well, it is placed on an even surface to rest for an hour. Coarse grains will settle first, with gravel on the bottom and sand on top of that. Silt however takes about 45 minutes to settle, and clay stays in suspension for more than 8 hours. This test is not fully reliable as the gravel layer will contain many voids and seem comparatively deep, and the silt and clay will swell up in the water. Still, it is a helpful indicator to distinguish the ratio between the coarse and fine particles, and it gives insight in whether there is a reasonable distribution of the particles. Generally, if the two layers of fines on top of the coarse particles are between 25 and 50%, the soil seems promising for earth construction (Schildkamp, 2009).



Jar test, segmentation of the different particle sizes (CRATerre, n.d.)

Developing a method for field testing

It is only by making a few test blocks that the actual strength and behaviour of the soil used in construction can be known (Schildkamp, 2009). This is due to the variances in composition and structure of the raw material, and in line with the procurement procedures of Erden (2022) as well as the testing methods described in Rammed Earth Consulting's code of practice (n.d.).

Laboratory tests are the most accurate ones, but far from always the most suitable. Access to a laboratory, expensive equipment and even electricity makes it an unsuitable alternative in many cases (Schildkamp, 2009).

In order to have a pressure testing method portable enough to be brought into the field or onto a construction site, a demountable rig to test 1 dm³ rammed earth blocks was developed. By tightening a nut at the end of a lever, the force applied on the block is measured by a scale and converted to MPa, force per area unit. The method is intended as a comparative testing method to complement and deepen the understanding of the sensory based methods described by Schildkamp.

In a first application, test blocks were made with

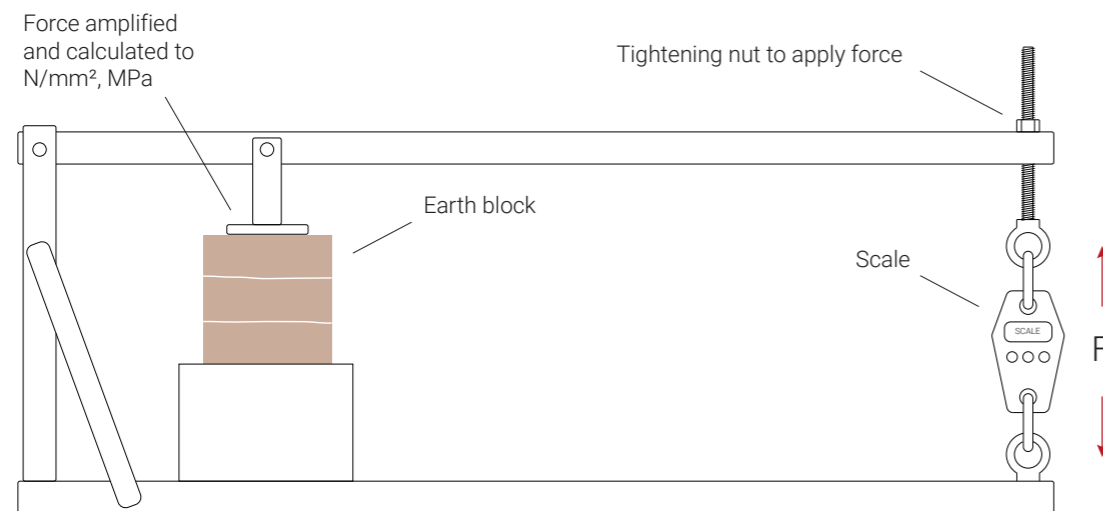
four different clay contents to investigate what an optimal clay content in regards to compressive strength would be, and how this relates to the visual, touch and jar test. Due to the low need for special equipment or conditions during the drying period, the production method of choice was rammed earth. By combining theory and practice – sensory and quantifiable test results – an intuitive understanding of the material properties and its different components was developed.

An unknown mix was included in order to test the method in a soil identification process. Conclusions drawn from this test are mainly about recognising a suitable clay content. There is a clear peak of compressive test performance between a clay content of 15 and 20%. There is also a clear difference to the feel of the soils with a lower and higher clay content – the 10% mix had a definite sandy feel and was easily made too wet in order to comply with the drop test. On the other hand the sample with the highest clay content, 25%, was distinctively sticky, both while mixing and ramming.

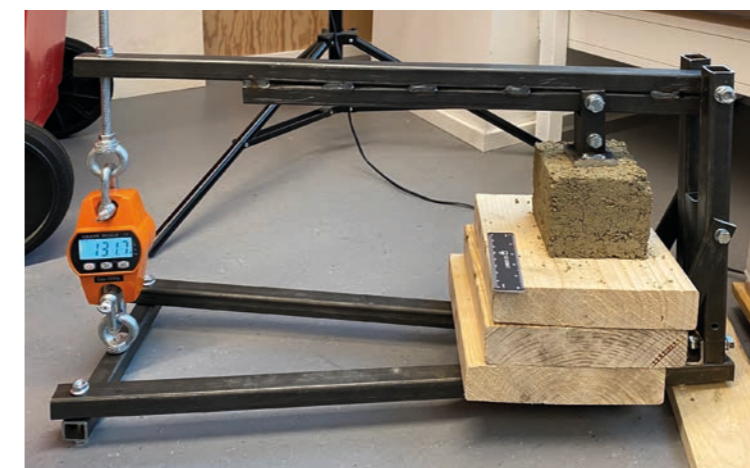
The increasing gap between crack and failure value with the rising clay content attests to the clay's lower compressive and higher tensile strength properties.

Results:

Clay content (recipe)	Mixing and ramming	Test performance (crack/failure value)	Jar test
10%	<ul style="list-style-type: none"> Hard to form a ball for drop test Sandy feel, non-sticky Floating around a bit while ramming 	2,5 / 2,9 MPa	12%
15%	<ul style="list-style-type: none"> Fairly easy to form ball for drop test Sticks slightly on the rammer Compacts well 	3,6 / 4,3 MPa	15%
20%	<ul style="list-style-type: none"> Easy to form ball for drop test Sticks a bit to the rammer Compacts well but floats around slightly upon excessive ramming 	3,0 / 3,8 MPa	23%
X%	<ul style="list-style-type: none"> Very easy to form ball for drop test Sticky, cohesive feel Sticks slightly to the rammer Compacts well 	2,2 / 3,2 MPa	25%



Sketch of prototype for on-site pressure testing



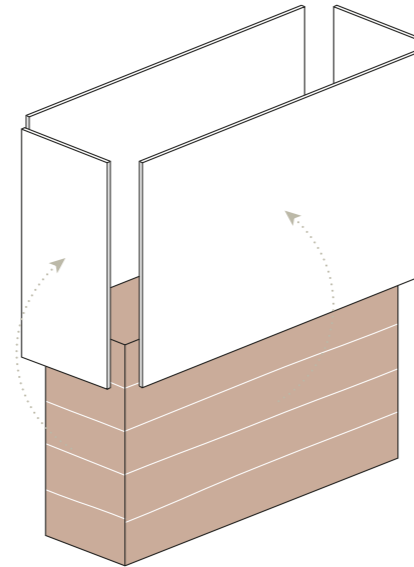
Test set-up



Failure of block

Upscaling and implementation in building process

To implement the developed testing method and investigate how it would work in an upscaled process, a prototype in a larger scale was developed. The goal was to acquire knowledge of the production and mixing process, detailing possibilities and overall formability of the material in a half scale rammed earth element. This was done in a workshop conducted together with AMU (Architecture Master students Union) at Chalmers, aimed at enlightening interested students on rammed earth and pass on the learnings we had acquired thus far. Small blocks out of soil with Gothenburg clay were rammed and tested simultaneously.

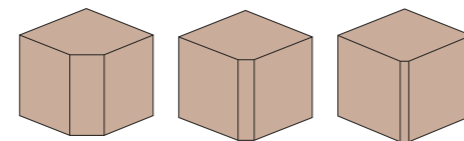


Process to shift formwork upwards

The process to move the formwork upward in multiple shifts and to integrate different types of shapes or block-out forms was tested in the prototype, as well as chamfered corners for less fragile edges and a vaulted opening instead of reinforcement with a lintel. Additionally an indentation was made to test ways of integrating more elaborate shapes into a rammed earth block. Pictures from the workshop are shown on the right.

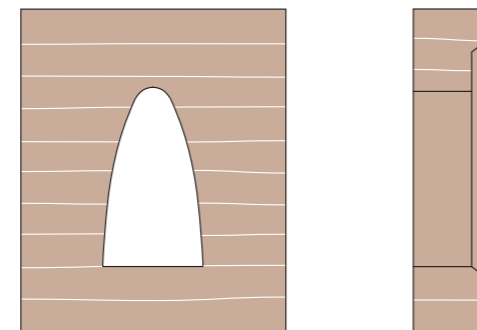
Result and learnings

The soil used was close to too wet, had a rather sandy feel and a compressive strength of around 2,5 MPa in the pressure test, indicating a clay content that was on the verge of too low. Additionally, the preparations with the form work, material procurement and mixing took 4-5 times longer than the actual ramming process, giving an estimation of the labor intensity of the construction method on top of the ramming itself, and how it increases exponentially with more intricate formwork.



Chamfers for less fragile edges

The workshop concluded the initial hands-on and collaborative learning phase of this project. In my mind, as someone without previous experience or relation to earth building, hands-on experience turned out to be something that earth as a construction material needs: you have to see and feel it to believe it. The learnings drawn from this phase were also of importance to the ensuing field studies: to have something to bring to the table in discussions and interactions with earth builders and other construction workers in The Gambia would be vital for making those interactions more equal.



Vaulted opening and chamfer inset



Finished prototype



Shifting the formwork upward



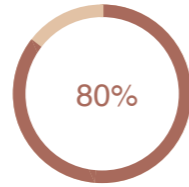
Workshop at Chalmers



Field studies

*A western architect finding a
role in The Gambia*

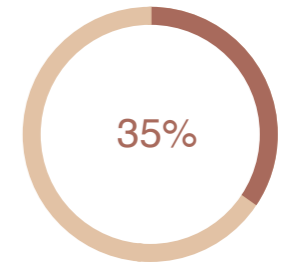
The Gambia



Energy saving building design
Building energy use can be reduced by up to 80% by using passive building design principles



Increased demand for construction materials
Floor area across Africa expected to more than triple between 2017-2060



Employment rate

35% of the labour force formally employed, the rest informally or unemployed. Agriculture provides subsistence to about 70 percent of the population



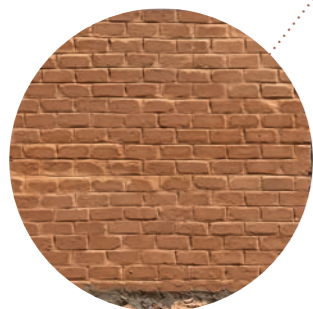
Value Engineering Construction

One of the few rammed earth building specialists in The Gambia



Earthworks Construction

Producing and building with compressed earth blocks, specialised in vault and dome constructions



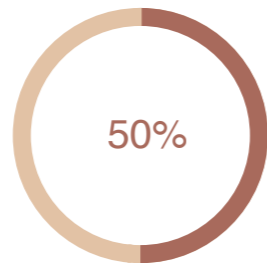
Eco building Construction

Builder of ecology houses in The Gambia, producing and building with compressed earth blocks



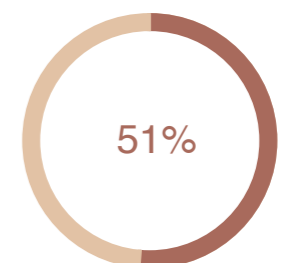
Build with Gambia

Building an Eco-arts village in Karsi Kunda, rural Gambia with vernacular methods



Imported construction materials

50% of the construction materials used in The Gambia today are imported, mainly cement and steel



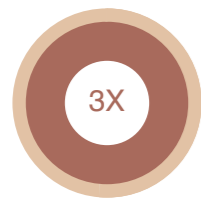
Existing earth buildings

51% of the existing buildings in The Gambia are built of mud, stone and compressed earth

Illustration inspired by United Nations Development Programme (2021)

The Gambia

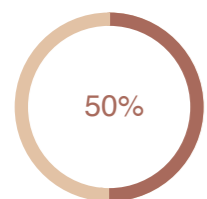
The Gambia is the smallest country on the African continent. The major cities are located either on or near its 80 km coastline in the western part of the country. The largest city, Serekunda, has 340,000 inhabitants, followed by Brikama with 77,000, and the smaller town Bakau and the capital Banjul (World Population Review, 2020). Sixty-two percent of The Gambia's population lives in cities, and the urbanisation and development trend across all of Africa, with floor area across the continent predicted to more than triple between 2017 and 2060, is evident also here with an overall population growth in which the rural population is gradually decreasing (World Bank, 2020).



3X
Increased demand for construction materials

Construction today

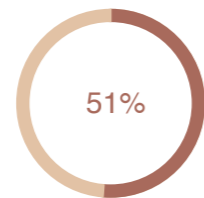
Today, Gambian construction is heavily dependent on imported materials, mainly cement and steel. With the increasing global development rate steadily driving demand and prices of construction materials up, an import based construction sector as the Gambian one is sensitive to global market fluctuations, which sometimes cause construction sites to be abandoned half-way through for years to await better market conditions. There is a forest and timber industry in the country, but getting hold of affordable and domestic sustainably sourced timber is difficult (Samba, 2023).



50%
Imported construction materials



Earth building is a traditional method in The Gambia just like in large parts of the rest of the world, with 51% of the existing buildings being made of mud, stone or compressed earth. However, in modern construction earth building is not seen as a viable option due to notions of low durability. During the rainy season in fall many of the traditional earth houses suffer damage as a result of structural deficiencies, flooding or insufficient over-head protection from the thatch roofs (Etu, 2023). Official regulations for earth building don't exist, and there is a general lack of interest for the material from government officials as it is still, in most people's minds, an unproven material unfit for modern construction, as opposed to concrete, steel or fired bricks (Samba, 2023).



51%
Existing earth



Rising awareness and interest

There is a rising interest in earth construction, mainly thanks to its affordability in comparison to concrete. Earth building is still a small niche in Gambian construction, but as more actors are seeing the potential of earth building and larger scale projects are starting to be realised, there is a generally increasing societal awareness and interest in the affordability and the technical as well as aesthetic qualities of earth building in the country.

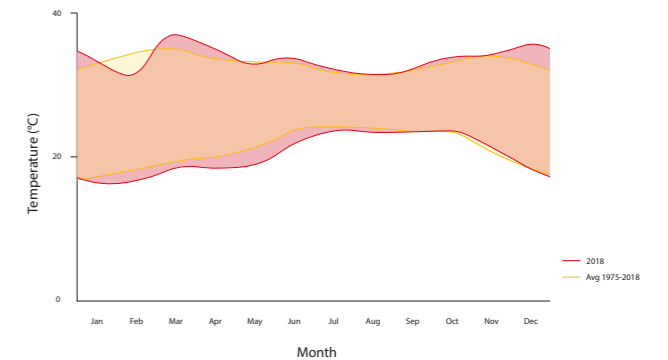
The UN Development Programme addresses the potential that the Gambian government has to stimulate skills and knowledge development in modern building design by optimising the use of locally available resources, and further argues that prefab construction can support housing development in urban areas by reducing costs, waste production and help move construction from the informal to the formal employment sector, an important aspect as only 35% of the labour force is officially employed today (2021).

Potential and challenges for earth building

The reasons for building with earth in The Gambia are plenty: to substitute largely imported construction materials with locally available ones would not only reduce global market dependence and make construction cheaper, it would also significantly reduce the country's international and national GHG emissions. More affordable construction and local material procurement and production would also result in new employment opportunities. Moreover, buildings of earth will benefit from the thermal buffering capacities of the material to cool the indoor temperature during the warmest parts of the day, minimising the dependency on air condition and fans reducing building energy consumption (Sonko, Wang, 2017).

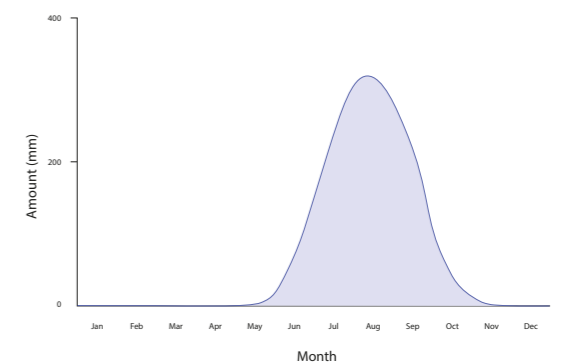
The main technical challenge for building with earth in The Gambia, both historically and today, is the heavy rainfall and risk of flooding in the coastal areas during the rainy season in the fall. However, the biggest hurdle for development of earth building is social acceptance of the material. Historical connotations to rurality and "cheap" construction make it a symbol for retrograde development, whereas construction with cement block represents the modernity and development to which individuals and society strive. Social acceptance as greatly dependent on how the material is presented to the public, as described by CRATerre (1991), points to the crucial role architects and planners have to play in promotion of earth architecture in The Gambia.

Monthly mean min/max temperatures

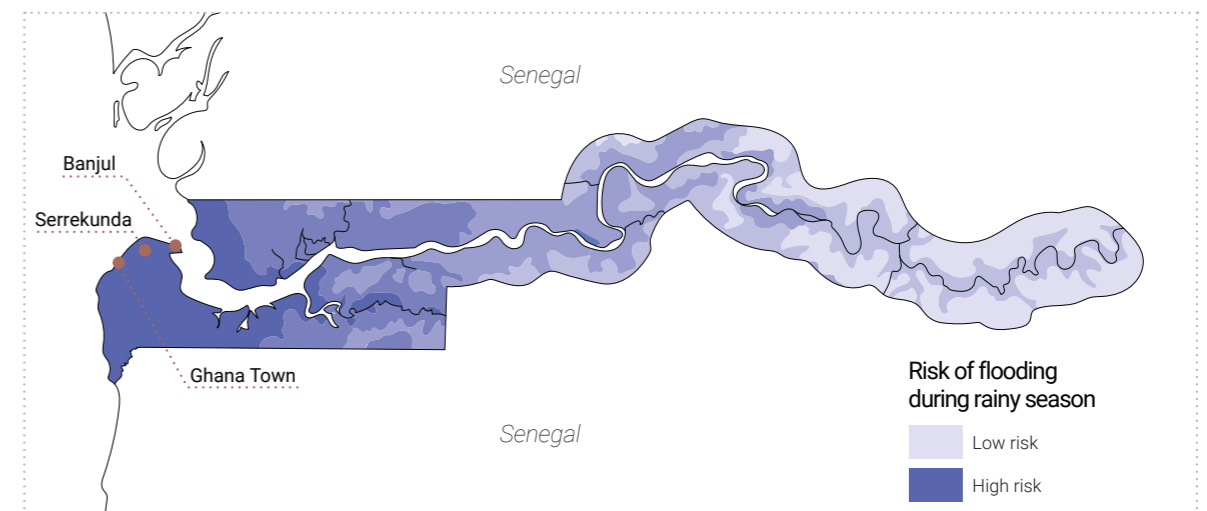


The thermal buffering capacities of earth is ideal for the Gambian climate with a wide thermal diurnal variation (climatedata, n.d.)

Precipitation



Amount of precipitation during the rainy season in fall (climatedata, n.d.)



Risk of flooding during rainy season (Ivacic et. al., 2019)

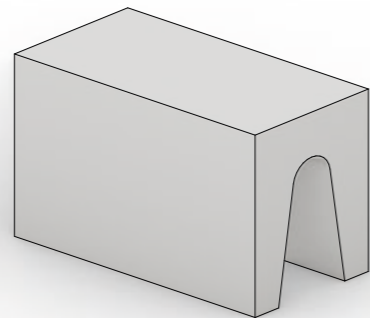
Gambian construction today

Construction sites for housing, hotels and offices can be seen everywhere in and around the cities. Road work and other infrastructure projects like flooding protection and drainage systems are being carried out as well, something that there is a dire need for as the the streets can be flooded to the extent that they're passable by boat during the rainy season. Not only one to three story buildings are being built, but also larger complexes of five to eight floors are starting to appear. The Gambia is country in development, and it's rapidly developing right now.

Dissociating from the vernacular building methods of rammed earth, mud covered wattle structures

and the so-called "sand blocks" (hand moulded soil blocks similar to adobe blocks), the prevalent construction method today revolves around the cement block. The process is based on two steps: first the structure is raised with a system of columns, beams and blocks, which is then covered with a layer of plaster or tiles for a uniform finish.

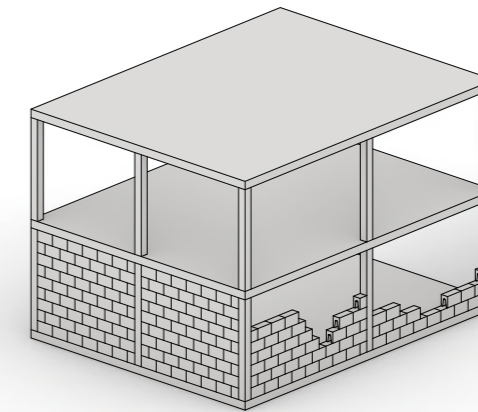
The structure is either made by casting concrete columns, beams and floors in-situ before filling in the walls with cement blocks, or by building the walls first and then casting the concrete within and on top of the walls, two methods distinguished by separate cast and masonry processes or a floor-by-floor progression.



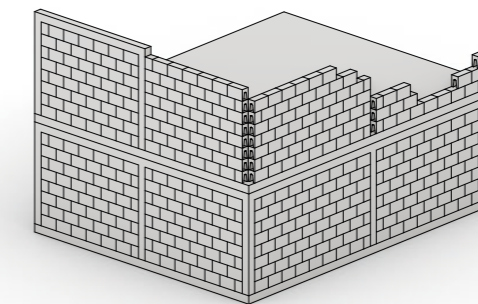
The cement block

As a symbol of durability, strength and dependability the concrete block, seen in a development context, represents modernity in the minds of people striving toward a state of higher development and modern life style. This idealisation partly has to do with the widespread use of concrete in industrialised countries, but also with the advantages the block presents in comparison to the previous, traditional building methods. A block is regular in size and technical properties making it easier to work with for the builder, and the cement gives it dependable durability and water resistance. A block is regular in size and technical properties making it easier to

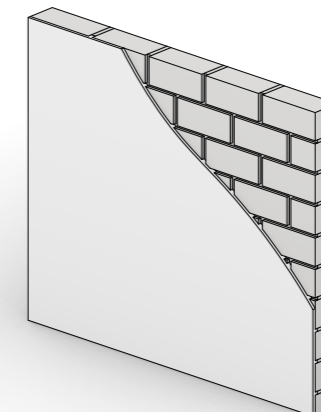
work with for the builder, and the cement gives it dependable durability and water resistance. Additionally, the block and the material represents a process through which a natural resource has been transformed and improved through industrialisation as opposed to the vernacular handcraft based methods, thus embodying industrial development and technological advancement which in the extension can be seen as the essence of development: increased standard of life with the help of technology. For not only structural but also cognitive reasons the cement block is the prevalent means of construction.



Concrete structure is cast in-situ before filling the walls with concrete blocks.



Structure is built by building block walls, concrete skeleton, then the floor slab before repeating the process at the next floor.



Construction process is built on covering a rough structural layer with a thin finishing layer



Hand-held mould for hollow concrete blocks



Structure built floor by floor, with concrete skeleton cast within the concrete blocks walls



The rough concrete blocks surface is plastered for a fine finish

Gambian earth building today

The prevalent earth building methods in the Gambia today are rammed earth and compressed earth blocks, with only a handful of actors working with it.

Earthworks Construction

Having commenced with earth construction already in 2007, in that time with both rammed earth and compressed earth blocks, Mr. Omar Jallow opened up a small niche in Gambian construction. After being requested to construct a project with vaults, he travelled to India to learn the vaulting technique with compressed earth blocks. Back in the Gambia, he realised a few earth block vault projects as well as developed the technique to build circular vaults – something he was invited back to India by his former teacher to present his experiences with at the Auroville earth building institute. Today, he's realising both small and large scale projects, working with both international architects and engineers as well as with local actors. He's also running training programs for youth with the help of international funding. According to him, a project made with his earth blocks is around 15% cheaper than one with concrete. His blocks can be combined with a concrete structure, plaster finish or made only with load bearing and exposed earth blocks.

Eco Building Construction

Mr. Fakeba Jatta is driven by ecological building principles. Having travelled to Senegal to learn the technique, he is back in the Gambia since 2010 building ecological homes, schools, lodges and community centres among other things. He integrates ecological principles such as local materials, passive ventilation systems, wood- and straw roof structures and seashell based plasters, and would usually integrate a concealed concrete structure within the earth structure. He started his practice in collaboration with Spanish architecture office Virai Arquitectos and is now running independent, carrying out projects as well as having training programs for youth.

Value Engineering Construction

Mr. Adam Samba studied and worked with civil engineering in the UK, both in the construction and infrastructure sector for over 20 years. Since coming back to The Gambia, he runs his own construction company, realising mostly housing or compounds for private customers. Having gotten a hold of formwork for rammed earth he started realising projects in rammed earth as a part of his conventional business. According to him, a rammed earth structure would save between 15-20% of the cost compared to a conventional concrete structure, depending on the finishing of the interior. The market is small, and usually the customers asking for rammed earth want the walls to be plastered, inside and outside.

Earth building on the rise

The rising interest and awareness of earth construction in The Gambia thanks to its affordability and local availability is boosted mainly by the two most prominent producers of and builders with Compressed Earth Blocks, Mr. Jallow of Earthworks Construction and Mr. Jatta of Eco Building Construction. They have found a niche for the environmentally friendly and affordable construction method, and have realised a multitude of projects in urban or semi-urban contexts where the blocks are on display and the reputation of them are starting to spread in society.

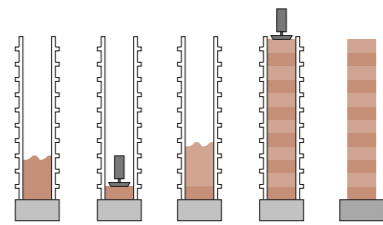
Other builders and actors in the construction sector are also starting to see the potential of the blocks. One example is the NGO Future in our Hands The Gambia, who are working to raise the interest of earth blocks construction with government officials. The low interest in earth construction from government officials as well as from architects and engineers within the country due to skepticism toward the material is holding back the spread and development of earth construction. However, there is a general sense in society as well as in the construction sector that the popularity of compressed earth blocks is on the rise and is the future in Gambian construction.



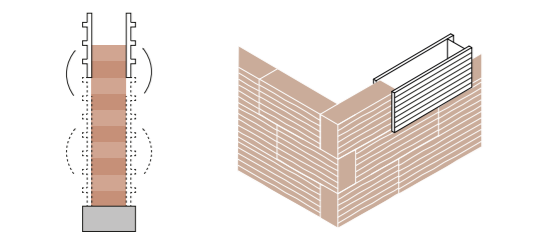
Rammed Earth

Ramming earth has been a method of earth construction for centuries in many parts of the world and the technique can produce buildings that are strong, durable, and desirable. Similar to in-situ cast concrete, the technique is based on forming wall elements by compacting earth in layers within a temporary formwork, which after removed form monolithic walls.

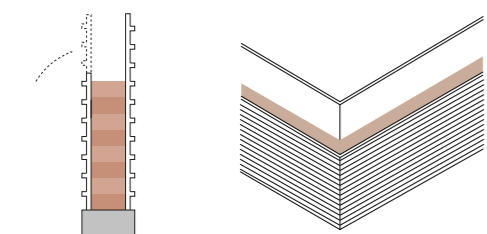
Provided formwork and ramming tools are in place, rammed earth is an affordable building method. Material can often be procured locally from the building site and the need for skilled labor is lower than with masonry and carpentry. This gives it a lot of potential in developing parts of the world where labor is comparatively cheap and unemployment rates are high, as a way to strengthen local economies by supporting local supply chains and generating employment opportunities.



Construction process of rammed earth (Anysz, Narloch, 2019)



Moving formwork: Both sides of the form are moved upward as the wall progresses

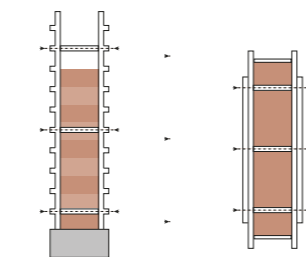


Fixed formwork: Form is added as the wall progresses

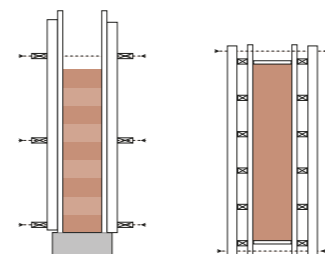
Since the 20th century, production methods have become slightly more efficient with the use of electrical tools, pneumatic rammers and more sophisticated aluminium formwork (Vyncke et.al., 2018). Still, rammed earth remains a labor intensive building method with preparation of the material and the formwork requiring as much or more of the invested labor than the actual ramming (de Morsier, n.d.). The labour intensity and the high dependency on the human factor (in the ramming process) for structural performance are the biggest obstacles for rammed earth in industrialised construction.

Rammed earth in industrialised contexts

Erden in Austria has developed a method for prefabricating rammed earth wall elements that can be stacked as over sized bricks to realise large projects. The method has been used successfully in a number of projects, for example the Ricola Herb Centre in Switzerland (Erden, 2022). Prefabricated rammed earth requires more infrastructure on the building site with large cranes and heavy material transportation. Yet in industrialised contexts where labor is expensive and the need for constant and dependable material performance to meet standards is a fact, prefabrication and automated processes like Erden's are needed for large scale implementation (Heringer, n.d.).



Fixing by rods through the wall



Fixing by rods outside the wall and reinforced formwork



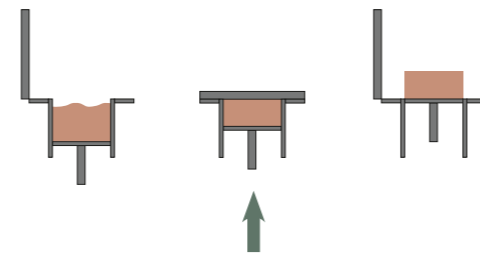
Moving and fixed formwork in rammed earth project, Zambia (Rammed earth consulting, n.d.)



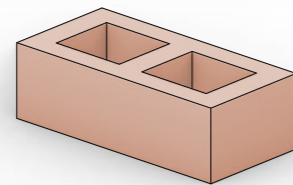
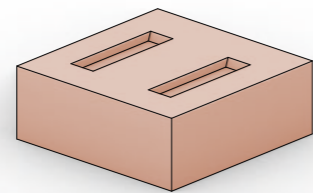
Erden's automatic rammer, feeding material and ramming up to 40 m of wall at a time and cutting elements to size (Erden, 2022)

Compressed earth blocks

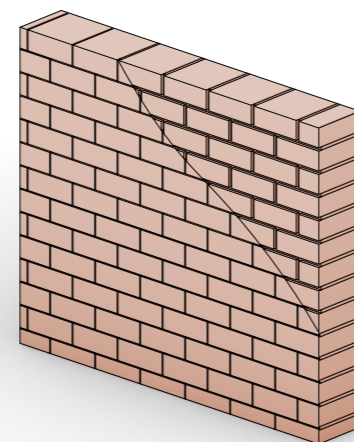
In view of the history of earth construction, compressed earth blocks is a new technique. Developed in the 1950's in a research program concerning rural housing in Colombia, it is an improvement of the traditional hand moulded earth block technique. The soil, slightly moistened, is compressed in a steel form to create the block. The blocks produced can vary in shape and size depending on the machine that is used, and the form can further be divided in halves, thirds and quarters in all three dimensions, giving the blocks a multitude of possible dimensions. They can be either solid or hollow with room for a concrete skeleton to be cast within (CRATerre, 1991). Since the block is put through a high compressive force in the production, the block is considered to be stronger than a concrete block. The drying time is between two to four weeks after compression, and in the case of Earth works and Eco Building construction, approximately 5% cement is added to the soil for increased strength and water resistance (Jallow & Jatta, 2023).



Production process of a compressed earth block



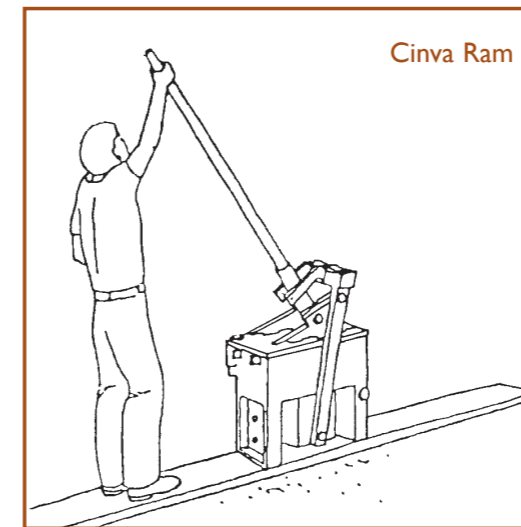
The blocks can be solid or hollow, and have many different dimensions and shapes, depending on machine and form



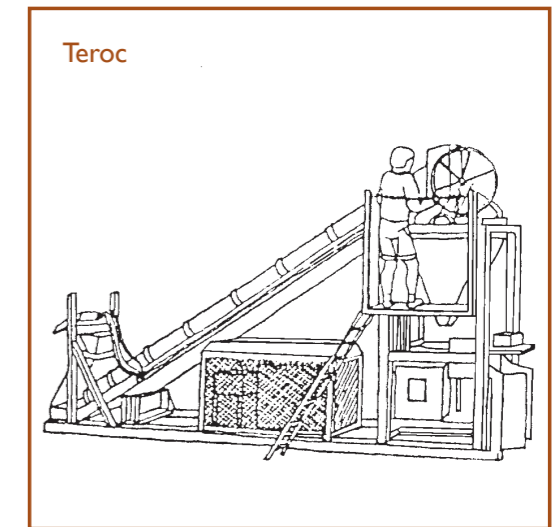
The finished block wall can be left with the earth surface, with touched-up brick joints, or be plastered

Sufficient compression as well as proper soil mixture is essential to produce blocks of adequate quality. The compressive strength of the blocks can vary greatly between 2–8 MN/m² which shows the relevance of using appropriate soil. For one and two-story buildings, 2.8MN/m² or more is generally sufficient (Adam, 2001), however good soil selection and appropriate design are two just as important parameters for durable CEB construction (CRATerre, 1991).

The process of making and building with earth blocks is similar to the one with cement blocks: they are prefabricated, walled up as infill or load bearing walls and then finished with a layer of extra mortar in the brick joints. Plastering is also possible. They could be produced both on site with a smaller, portable machine, or in a more industrial process in a factory with automatic compression, mixing and soil feeding (Adam, 2001). The Compressed earth block provides an alternative between traditional, low grade techniques and modern imported materials – it constitutes a standardised way of earth production based on local resources and labor (CRATerre, 1991).



The Cinva ram, one of the original manual compressed earth blocks rammers (Adam, 2001)



Teroc, a hydraulic machine automatically mixing, feeding and compressing the soil (Adam, 2001)

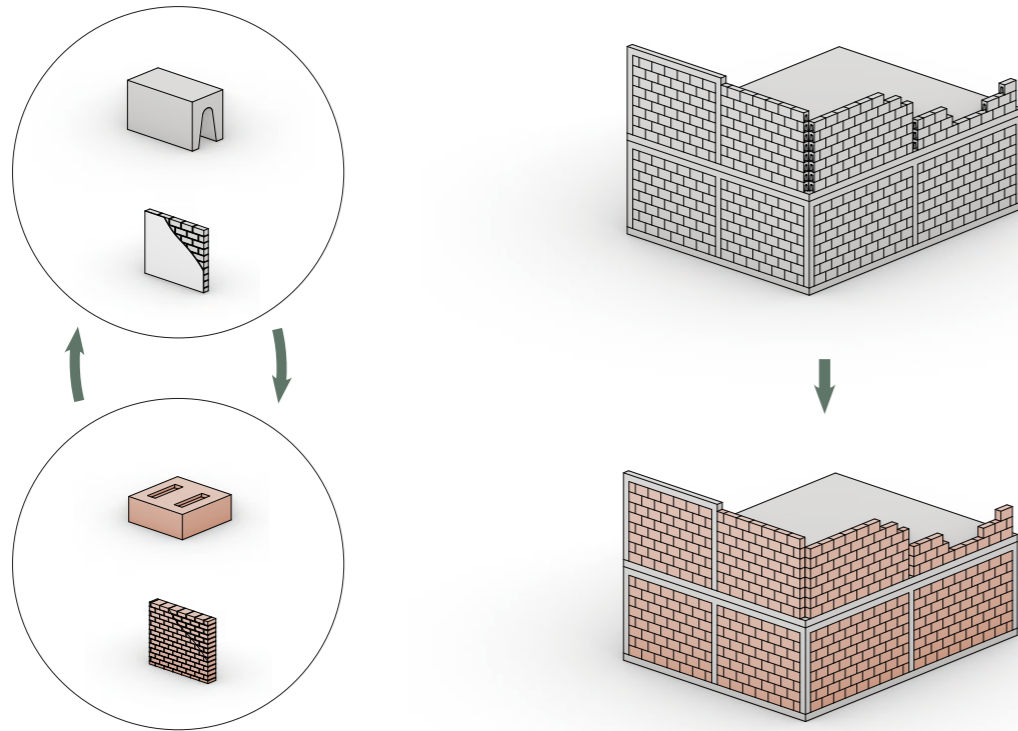


Plastering the brick joints of a compressed earth blocks wall in Kanuma, The Gambia.

Compressed earth blocks in The Gambia

There are a few reasons why compressed earth blocks has become the primary method of earth construction and is seen as the future of construction by promoters of earth building in The Gambia today. First of all, the method is similar to the existing building practices with concrete blocks and is practically interchangeable without having to adjust too much in the construction process. A manual or automatic block press is needed and that's all. Secondly, the blocks constitute a form of standardisation that is needed in modern, upscaled construction. Size and shape as well as performance is more dependable thanks to the way they're produced. Finally, the block itself as a symbol of technical advancement and development also applies to the compressed earth block. In contrast to the concrete block however, it also speaks to the country's cultural heritage by reminiscing of the vernacular mud block technique, but in a modernised and technically improved way.

In a country like The Gambia where unemployment rates are high, the case for construction with earth blocks has added relevance as the method builds on the masonry culture and competencies already in place, adding employment opportunities for workers to use their labor skills in new guise. Furthermore, the prefabrication aspect of the production process is in line with the goals of the government's and UN's development plan to increase prefabrication processes in order reduce costs, waste production and help move construction from the informal to the formal employment sector (UN Development Program, 2021). The Compressed earth block as an alternative between traditional techniques and modern imported materials, using national labor and local resources as described by CRA Terre (1991), is already set up and has started to spread. What is needed for it to expand further is more exemplary projects, and more opportunities to showcase the method and its diversity to raise awareness and increase desirability of earth construction in The Gambia.



The earth blocks construction method is practically interchangeable with the current concrete blocks construction method



Construction site in Sanyang of Eco building construction showing the process of raising the walls to cast concrete structure within it.

Being a western architect in a developing country

There is a high degree of sensitivity and questions that can be raised toward planning an aid project in a foreign context, particularly coming from an industrialised country with an ambition to implement a certain way of building, living and educating in a developing country. The stakes are raised even higher when the context is a school: a manifestation not only in the built environment but also in society of education, hope and future. The function and use of the building will adapt and change over time according to societal development, but the building itself, designed in a momentary instant in relation to its full life span setting the spatial confinements within which those activities take place, will leave its mark on the society it's built in for several decades. For an external architect, the project will be one in a long line of other projects where the influence on and responsibility for it largely stops at the time of its realisation. But for the users and local actors involved the effects of the project will extend far beyond that. The difference in responsibility, time scale and consequences is high, an aspect all too important if the project is to be truly successful in its aim to provide inspiration for and signal hope and a better future. A deep cultural understanding of where the country is coming from and where it's headed is needed, and in the case of an external western architect with knowledge based on a completely different context, this can only be obtained by taking a step back from the role as a sole designer and extensively involving local actors in the project.

Need for mutual benefit

Why would a Swedish architecture office get involved in the planning of a project like this at all? The general objective of Eivor Björkman Elementary to provide and boost education and help a developing society give children a chance for a better future in The Gambia is clear: there is a definite need for this in the country. Why would a Swedish architecture office stand for the planning and design of it? Why wouldn't a Gambian architect, with far more knowledge of the local context and building industry get the chance to do it, and the Swedish architect instead volunteer to do the same work domestically, in say Angered, Botkyrka or Rosengård, all areas that could benefit

from additional investment and boost in education for the future. In a project where no final customer is asking for a specific design or material and the outcome will be a symbol for the future affecting children and their families for a long time, The Gambia shouldn't be treated as neither a testing ground nor a place to do the Gambians' work for them. To motivate this kind of work there has to be some type of mutual benefit obtained from working in between these two particular contexts.

Niche for a western architect

In The Gambia there is a rising industry for compressed earth blocks construction that is noticeable in society by an increase in public awareness and realised projects. Still there is a low interest from Gambian government officials, architects, engineers and representatives for the building industry in earth building as it is deemed an unproven material for the future. There is not an issue of knowledge of the possibility of earth construction, and also not whether it works structurally or not: this is already something that's being proven by the existing earth building practices. What is needed are more examples showcasing the diversity and potential of earth building, honouring the material itself and it's own unique properties. This is a role that an architect from a western context, where an interest in earth from a designer's perspective is already being established, could fill in The Gambia today in order to support the spread of earth building to other levels of the construction sector.

Knowledge exchange

What they have in The Gambia with the current earth building industry in place is something we are lacking in industrialised contexts, particularly in Sweden: a method for building with earth that is adapted to industrialised building processes. While a Swedish architecture office can provide a designer's perspective and interest in earth building, the Gambian earth building industry can provide knowledge on building with earth in this type of industrialised process, which would make up a platform for the mutual benefit and knowledge exchange that would motivate this type of work, within this particular context.

Knowledge exchange and mutual benefit is what turned out as the focal point of my project, after interactions during the field studies guided the process and transformed the objective and purpose. While the initial intent of the work was to explore potential for building with rammed earth in The Gambia and provide that perspective to the planning of Eivor Björkman Elementary, the interactions with people and learnings about the cultural context gave new perspectives on more adequate and contributory ways of, as a westerner, promoting earth architecture and supporting development of earth building there.

Conflict of earth building methods?

Personally I felt that advocating for rammed earth as an outsider, in a context where earth building propagators are aware of the technique but passionately believe in another, put me in a spot where I had to either assimilate the local context, or pursue an own conviction despite the new insight and changed perspectives. The compressed earth block and rammed earth have many similar advantages: they are produced from locally available soil, are around 15% cheaper according to Gambian earth builders and both contribute to a comfortable indoor climate. This led to a sense that a choice between the two building methods mainly would be one based on personal (or professional) preference. Coming from a developed context, I am well aware of the limitations of rammed earth in industrialised processes. As a western architect in The Gambia, is it my place to push for such a method, even though it would create division in the current earth building industry that is already competing with the conventional one? If the objective is to help promote and spread awareness of earth building in The Gambia, the answer is no. And if the objective is to design a building based on the local prerequisites for a future with earth architecture in Gambian development, the answer is probably also no. Does this mean there has to be a conflict between rammed earth and compressed earth blocks? Not really, rammed earth offers its own unique advantages and certainly can have a role to fill in The Gambia, just like in Sweden or any other country. But the limitations of rammed earth in developed contexts, and the contrasting flexibility that the earth blocks offer, are aspects

that need to be acknowledged and taken into consideration when the objective is to promote earth building in The Gambia.

A change of my own perspective as a result of interactions also goes for the use of cement stabiliser in the soil, an aspect that takes away from the natural purity of the material and its ability to be fully recycled at the end of its life cycle. But if a Gambian says "I put cement in the mix to be able to sleep at night" – who am I to say it's wrong? As a western architect, we could propose ideas but not impose concepts: we're not the ones who would be affected by the consequences of it.

What are you doing here?

As a recurring question I was asked, purely out of curiosity and with no ill intent, it made me reflect on and consider exactly what I was doing in The Gambia, and how I would convey that to make the most out of my interactions in search of potential collaboration partners. "I'm here to teach you about earth building" would be downright offensive as it would imply an intention of teaching Gambians about their own cultural heritage, which they either would be striving to depart from, or would know more about than I ever could. In other words not a way forward. "I want to learn about earth building here because you have both contemporary and traditional knowledge" could spark some enthusiastic conversations, but put the dynamic of the interaction in a teacher-student situation, not beneficial for the mutual knowledge exchange objective. If a lasting interaction for knowledge exchange was to be established, which was essential to the project, I needed to be able to offer something to offer in return.

Instead I focused on wanting to look into what a Swedish academic perspective could bring in order to provide new perspectives and potentially help develop Gambian earth building practices, and in this process work in a collaboratory workshop to develop a prototype while learning from each other. With these prerequisites, I got positive response from Alpha Jallow who was interested in partnering, as he expressed it, in this venture. The wording was important as it set the conditions of an equal working relationship from the start.

Workshop with Earthworks construction

To provide the intended platform for knowledge exchange and create an example of a collaborative design process to explore new perspectives on earth building in The Gambia, I had intended to organise a design and build workshop together with local actors before coming to the Gambia and knowing what the objective of it would be. A need for the perspective of a local earth builder was clear, and Jallow was interested. But what could an architecture student provide to make it worth his time? And how to make the focus on collaboration rather than teaching? With limited funds, the objective of the workshop needed to extend beyond economical benefit for the builder, and would also need to bring a type of perspective that normally wouldn't come from his regular local collaboration partners.

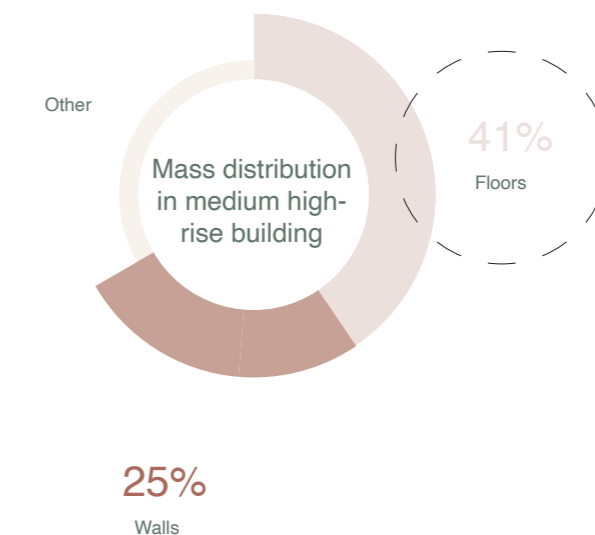
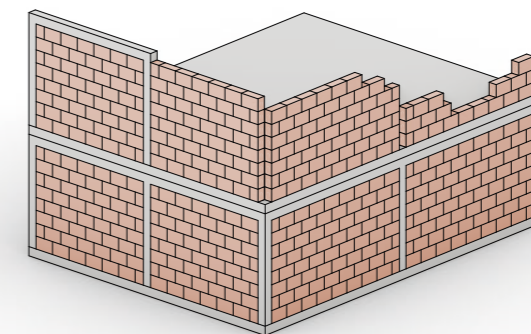
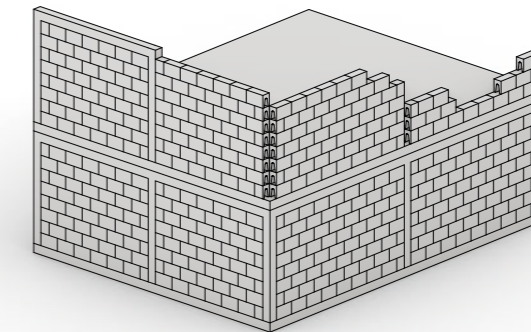
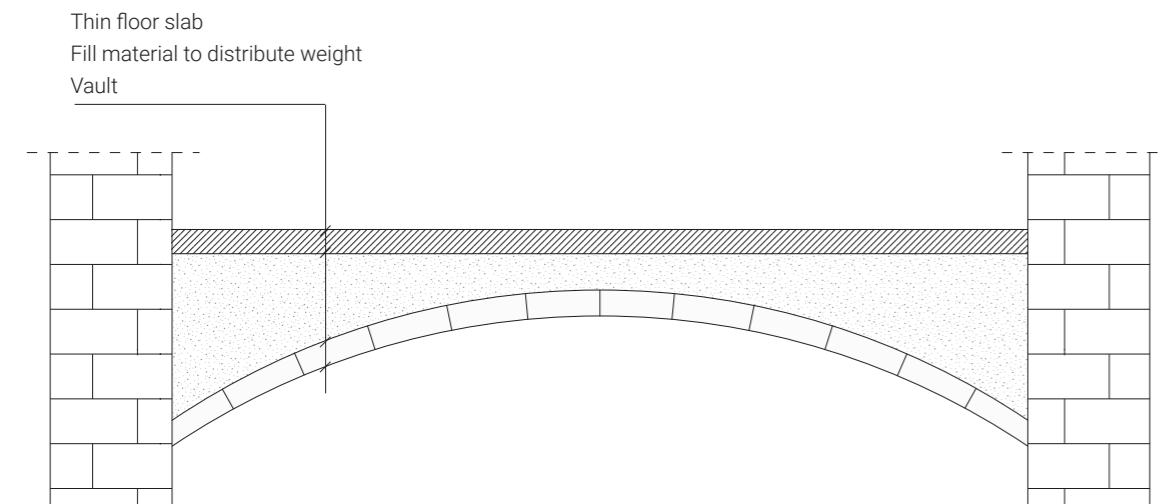
Earth, as one of the solutions for a carbon neutral construction sector in sustainability discourse, can easily replace a conventional concrete wall in any building with the methods of Jallow's Earthworks Construction. However, by replacing concrete blocks walls in a medium high-rise building with earth blocks, the mass of the total building that is replaced by a low-carbon material would sum up to no more than 25-30% (Block, 2021). This shows the relevance of exploring potential use of earth also in the horizontal elements of buildings, the floor slabs.

The workshop was carried out together with the

engineering students in the parallel project, and drawing inspiration from the research of Philip Block at the ITA at the ETH in Zürich on material optimisation through design and compression-only structures, we introduced the idea of timber vaulting, a method for building thin and shallow vaults. Through calculations we could show the low force exerted on each tile in a timber vault, which convinced Jallow to try the method with his compressed earth blocks. A timber vault floor slab could be integrated in the structural system he's already building earth structures with, where the blocks are complemented by a slender concrete skeleton, and it builds and expands on his current expertise with vault and dome constructions. As shown in the figures on the following page, there is huge potential for both concrete and steel reduction in structures.

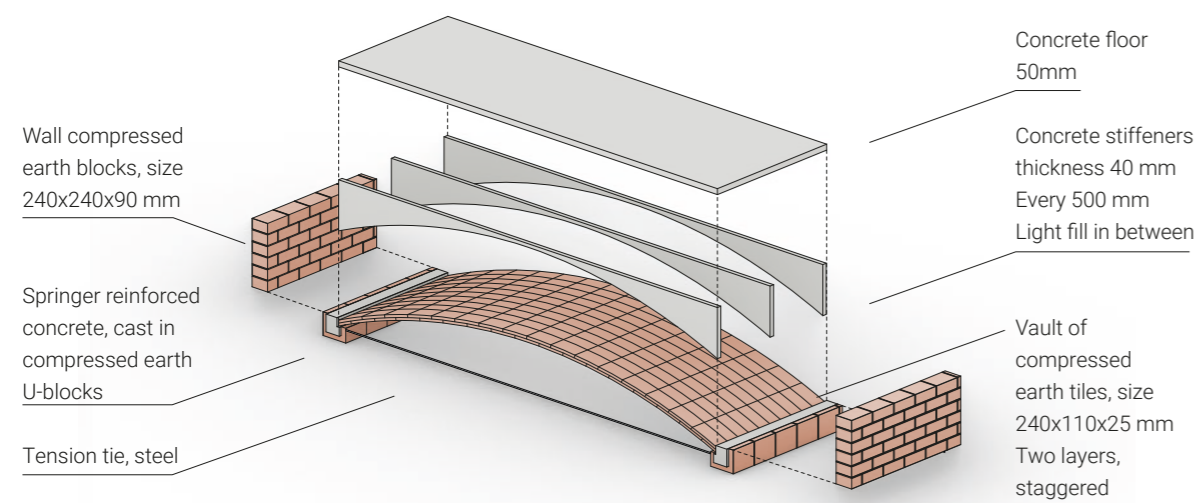
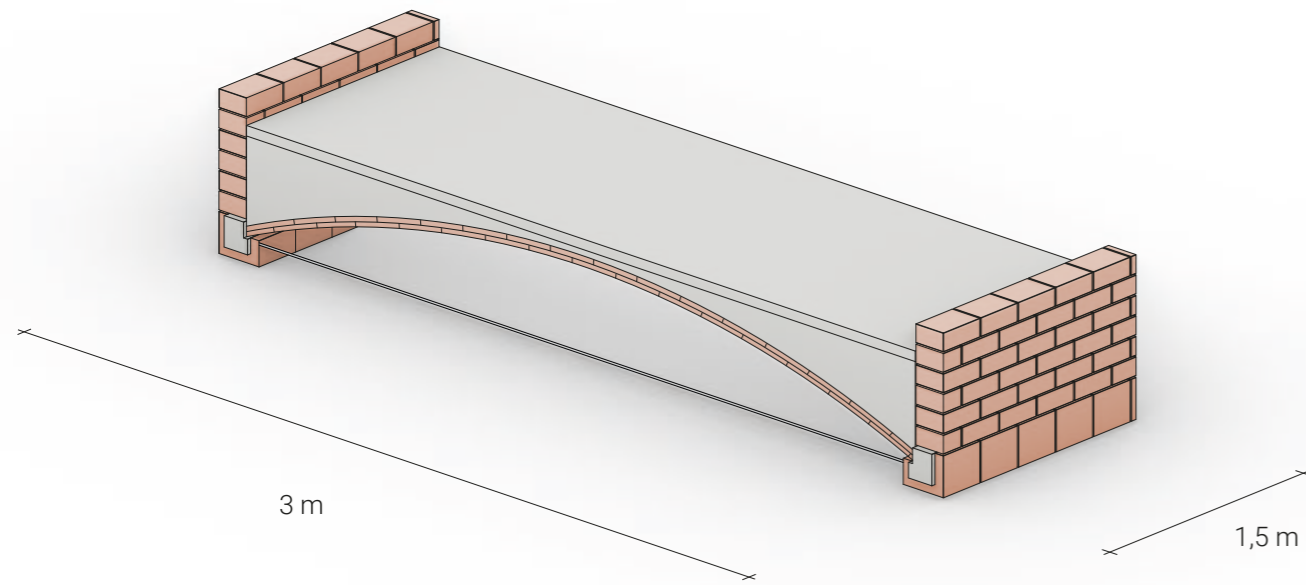
To explore feasibility in construction with Jallow's methods as well as how the reduced material would compare to the cost of labor and production became the prerequisites for the workshop. In the process we would work together by bringing our separate expertises to the table while respecting and seeing each other's. The aim was not to be one another's teacher, but to work together and in this process get insight into each other's field of expertise: architect, engineer and craftsman in order to generate mutual knowledge exchange.

Principle of vaulted floor slab

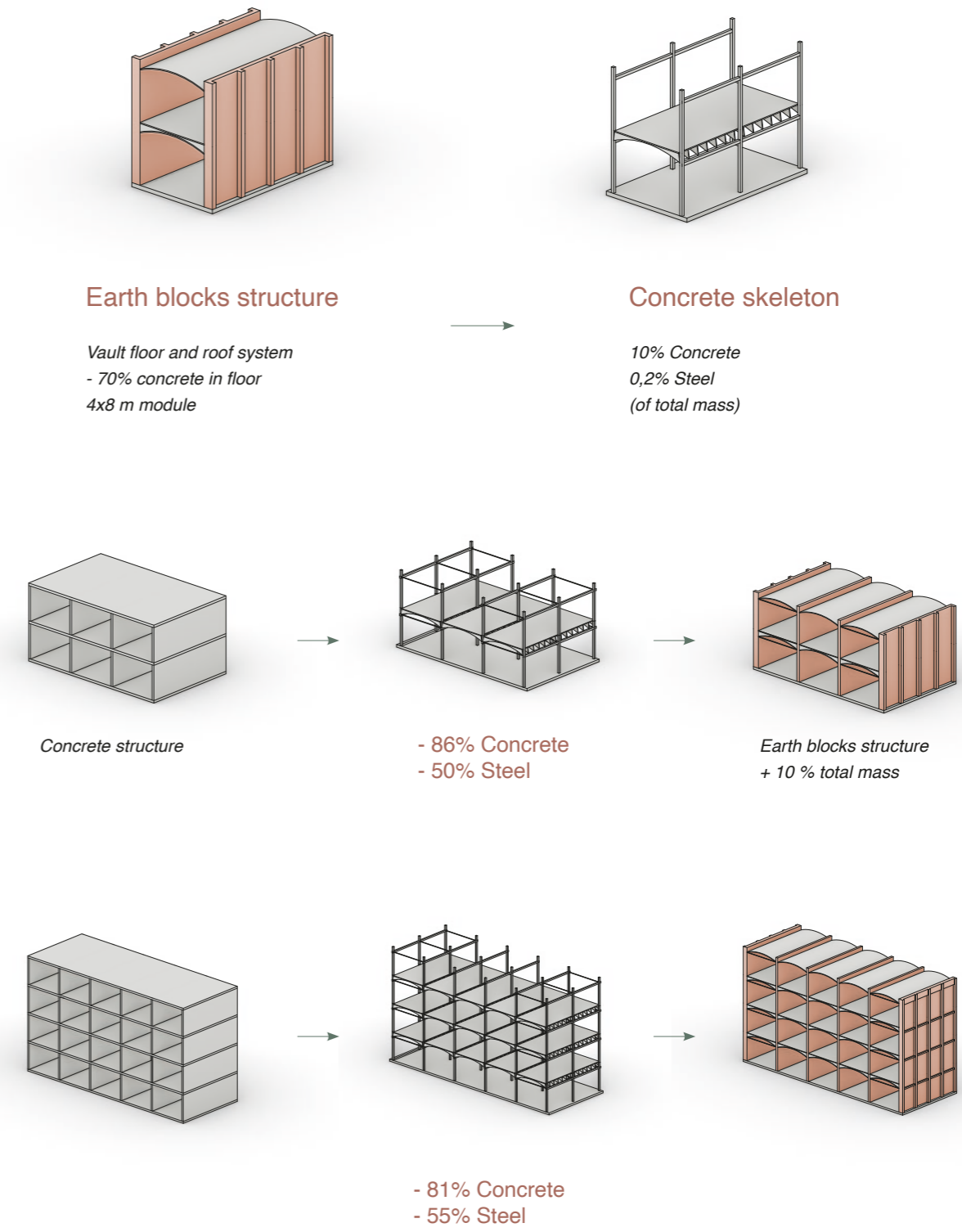


Mass distribution in medium high-rise building (Block, 2021).

Prototype



Potential implementation



Estimations based on 150x150 mm concrete beams and columns reinforced with four pieces of 16 mm steel, 200 mm concrete floor slab reinforced with 8 mm steel net (125 mm squares), 150 mm hollow concrete blocks walls, 240 mm solid earth blocks walls.





Preparing the soil



Finding the right settings for the machine to setup production



Mixing the mortar



Building the walls on which the vault would stand. Blocks need to be leveled horizontally and vertically.



Wall is ready to cast the springer, concrete beam on which the vault will rest.



Aligning the formwork for the vault.



Progression of the vault



Fitting the final piece: the key stone.



Finished floor slab – it held!

Result and learnings

The workshop, conducted on a site where Jallow had his office and carpentry workshop, was a long process but in the end a success. Together we managed to test the principle of a vaulted floor slab in a prototype, he got proof of its feasibility and we got knowledge of the construction process with compressed earth blocks, from block production to finished-up mortar joints. Naturally many of the learnings deal with the production and building process itself, but the learnings about Gambian building processes from trying to plan a project there were at least as many.

Plans and intentions always had to be counted on to change, and the process and goals had to be adjusted constantly in order to fit the prerequisites of that specific moment. Sometimes the build would be fast and efficient and sometimes it would stand almost still for several days. As an otherwise very busy man, he would give us a lot of trust and own responsibility in the construction in a normally extremely hierarchical industry, which was both challenging and fulfilling. He would show a few steps on the way and then let us continue. When he was gone, we would work together with his sons and other colleagues of his that joined in every now and then, some out of interest, some out of intention to teach us as well (with more or less successful results). Thanks to its location and water pump his place was where the locals would come to get water, which meant a lot of movement in the area and other people seeing and being interested in the prototype.

The construction was carried out in a constant dialogue with Jallow, where he would bring most of the expertise but at the same time was open for changes based on our input. Apart from the design and engineering perspective, there were also workflow and woodworking aspects I could contribute with that would improve the result or speed up the process. The final result was a version of the prototype adapted to the conditions at hand: the blocks for the vault had to be made slightly thicker than we intended so they wouldn't break (some still did in the construction process), the fill material was made with saw dust mixed with sand and cement and the springer and tension tie had to be adapted to the size of the pre made steel reinforcement beams. Nevertheless, the workshop was successful and we managed to pursue the intended process in a way that fulfilled the goals of both parties.



Summary & conclusion

Summary

This project is placed within the context of the current sustainability discourse on earth as one of the solutions for a climate neutral global construction sector in strive towards sustainable development. It has addressed the need for increased knowledge about earth as a building material among architects and other actors in the construction sector through a hands-on and practical learning approach, in an effort to develop an intuitive and artisanal understanding for the material to complement theoretical knowledge. It addresses the challenges for spread of earth building in developed and developing contexts by proposing a collaborative architectural approach.

In The Gambia, the project has identified what type of role a western architect can fill in order to help promote earth architecture. It has proposed reasons as to a Swedish architect working on a Swedish initiated school project, and it has stated an example of a collaborative design process with local earth builders in which the results render mutual benefits and help tackle the challenges of earth building in both contexts: they acquire new perspectives and opportunities for their existing practices through architect and engineer involvement, and we gain knowledge about an earth building method adapted to industrialised processes. The project has touched on the structural and aesthetic properties of compressed earth blocks, and it has re-imagined the initial design concept for Eivor Björkman Elementary based on the current state of Gambian earth building. The hope is that the local perspective can help develop the school into a project that will respond to the challenges of earth building in The Gambian context today, and accordingly manifest a way forward for a future with earth architecture there.

This project is not a case for or against a specific building method, nor does it propose a new design for a school building in The Gambia – it aims to show how a collaborative and participatory process in an aid work project can result in mutual benefits, and how interaction with the local culture can lead to a change of perspective in regards to how a western architect would intend to provide *help* in a developing country.

Conclusion

A Swedish initiated earth school project in The Gambia can provide a platform for knowledge exchange that will contribute to developing earth building in both Sweden and The Gambia by adopting a collaborative rather than consultative architectural approach. With a well considered analysis of how the project fits in to the current Gambian earth building situation, and by inviting to conversation held on their terms, participation from local actors will be inspired and a process of working together rather than for one another is initiated. An equal working relationship is key in order for the venture to be mutually beneficial, without it the process risks turning lopsided: if the Swedish architect alone is dictating the terms of the collaboration, there are no new insights gained for the architect and the process turns into a traditional architect-contractor relationship, which a Gambian architect just as well could assume. If the contractor is to dictate the terms alone, there are no new perspectives or insights gained for them, and in the process the contractor would turn into more of a teacher than a collaboration partner. By stepping out of the traditional role as a pure designer and putting the occupational roles of architect and contractor aside, this kind of collaboration will be possible – eagerness and interest to learn from one another, from both sides, is necessary. This opportunity for mutual knowledge exchange gives reason to a Swedish architect doing work on a Swedish initiated school project in The Gambia.

In addition to that, the void of architect and engineer involvement in Gambian earth building is a role that a Swedish architect can fill without taking away opportunities for existing local practices, as there is a definite lack of domestic architect and engineer involvement in earth construction today. Filling this type of role has to be done highly conscientiously however: the ideas and concepts proposed and implemented have to be in accordance with the local context if the work is to act complementary to existing practices and provide future inspiration to local actors. If not, the work risks turning into a side-track in the country's development, derailing or even stagnating the development of the practices that are already in place.

Eivor Björkman Elementary

In regards to the planning of Eivor Björkman Elementary, the limitations of rammed earth in industrialised and developed contexts need to be taken into consideration when creating an example of earth building for the future in The Gambia. We are aware of these limitations in our context, and to a large extent, these are no different in The Gambia. Based on my interactions, largely for these particular reasons, The Gambians believe in a future with another earth building method: the compressed earth block. Offering practically the same physical and economical advantages as rammed earth, and representing a technically developed and improved version of the traditional technique, the choice of building methods for the school should be done conscientiously and for the right reasons. Additionally, it is vital to find the right collaboration partners, as there is a large discrepancy of knowledge about earth building within the country. Collaborating with someone practicing earth building already will increase the general benefits for earth building in The Gambia and result in beneficial knowledge exchange for both parties.

Learnings about earth in The Gambia

The learnings drawn from working in a country with traditional ties to earth building are mostly of practical and technical nature, but also offer an important perspective we are missing in countries without it: the apparent need for improvement and adjustment of vernacular methods to correspond to the demands and scale of industrialised construction. In The Gambia, there are many houses raised with traditional methods still standing. Some of them offer proof of the advantages and benefits with those methods, but most offer proof of the challenges as to structural performance, dependability and durability. They stand in contrast to the modern houses, acting as manifested examples in the built environment of what the country intends to develop *from*. This is an important difference to the view on traditional and vernacular architecture in developed countries, where it tends to be idealised and romanticised in another way, perhaps simply because we don't feel its presence in every day life in the same way.

Compressed earth blocks in Sweden

The Compressed earth block as an alternative for a traditional earth building method in an industrialised version can have interesting potential also in Sweden. It is easily implementable in current block working processes such as bricks or clinker blocks, its production is scalable to industrial levels with the manual factor in the mechanical compression minimised, and it offers the same indoor climate regulating benefits as other earth building methods. The susceptibility to water, as with all earthen materials, is a challenge, but in Sweden where the structure has to be covered with a protective layer for wind, rain and insulation purposes, it might work even better. There is still the aspect of high dependency on the raw material which requires knowledge and experience to navigate, but as Erden proves in their production of pre-fabricated rammed earth elements, material procurement procedures are also scalable to industrial levels. The compressed earth block offers many of the same advantages as rammed earth, might not provide the same aesthetic qualities but certainly comes with their own, and, most importantly, is a significantly lower threshold for a construction industry in dire need of change.

Compressed earth blocks in the future

Detailed studies on the effects that grain size and particle size distribution in the soil for compressed earth blocks have on their technical performance are proposed to be explored further. In the soil in The Gambia, the sizes were relatively small compared to what was used for the test blocks in Sweden – could there be room for improvement? The same goes for the use of cement as stabiliser to increase strength and protect the block from erosion caused by water – what effect does it have on the strength? And can design measures for erosion protection, similar to the ones of Erden, be taken instead to reduce the need for cement stabiliser?

To develop strategies for production and implementation together with actors from other parts of the construction industry will be essential to give earth building in the form of compressed earth blocks a chance for a future also here in Sweden, just like in The Gambia.

Gambian Earth building

The Gambian Earth building industry receives input on structural optimisation and design that results in new perspectives for expanded use of earth: structural design brings a way to use earth in the floors and roofs of a building, and a designer's perspective on the flexibility that the blocks offer can emphasise the versatility that sets it apart from other Gambian construction methods.

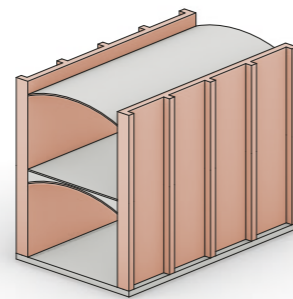
This combination could give the modern Gambian construction industry, currently highly dependent

on imported materials and generic concrete construction, the potential to develop its own identity centred around a local resource.



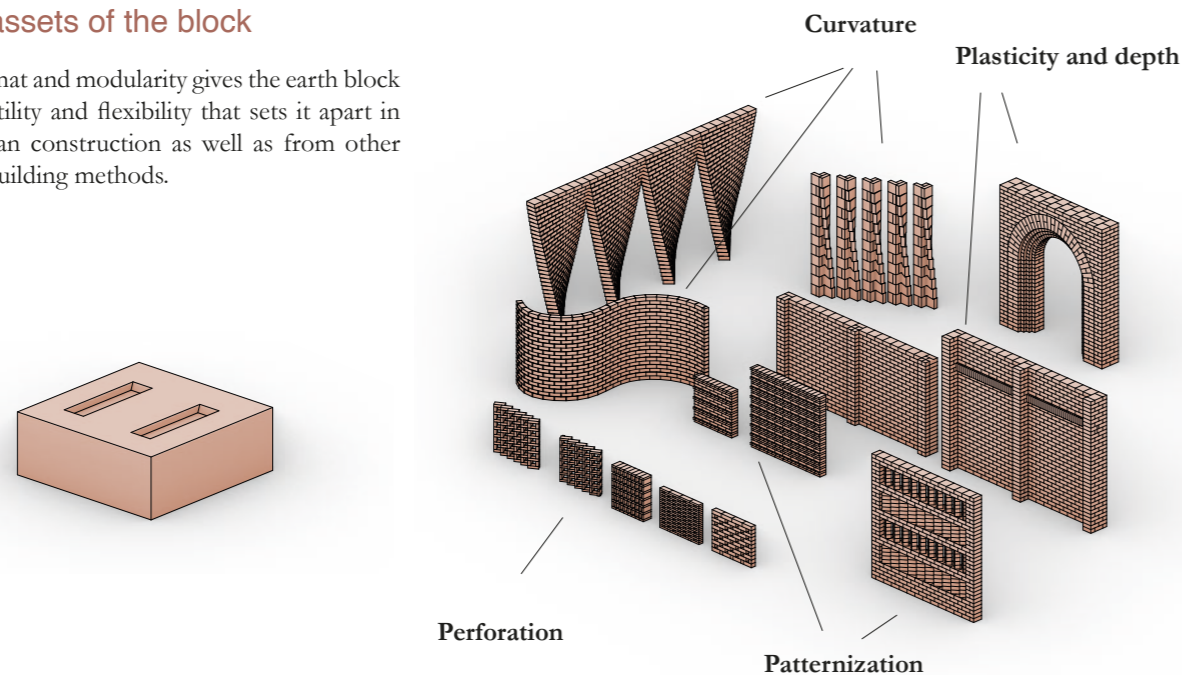
Earthen structural system

- Vaulted earth floor and roof system: 80–90% concrete reduction compared to conventional concrete structure



Unique assets of the block

- Its format and modularity gives the earth block a versatility and flexibility that sets it apart in Gambian construction as well as from other earth building methods.



Swedish Earth building

The Swedish building industry, currently not using earth to a significant extent, gets knowledge on building with a low carbon, circular material based on a resource that today is considered as waste. Its indoor climate regulating and moisture buffering properties make it complement wood well: it offers heat buffering capacities that wood doesn't, and will draw out eventual moisture from wood it's in contact with.

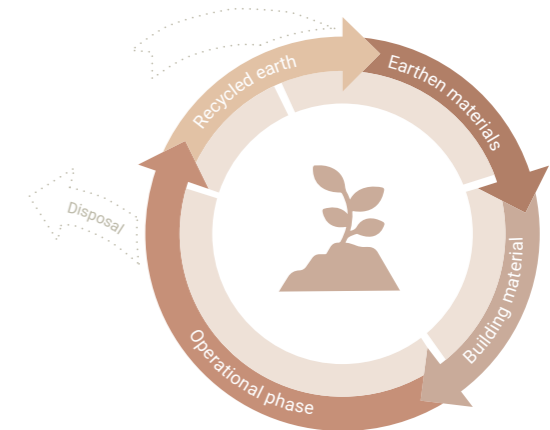
The raw material is a variable that requires knowledge and experience of specific local prerequisites to navigate, but the standardised format and constant exerted pressure in production makes it an earth building method with the scalability and predictability to provide an alternative to for example concrete elements, bricks or clinker blocks, but with less processing and better indoor climate regulating properties.

Construction waste as building material

- Potential for excavation masses to be re-used as construction material

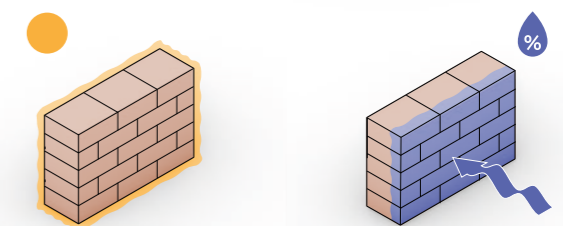
Low carbon, circular material

- Earth as a low carbon and circular material with relevance in sustainable construction and rising focus on material climate footprint



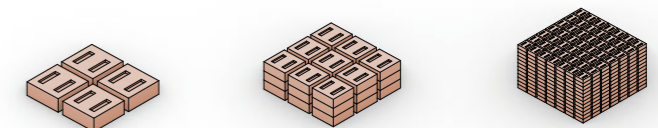
Indoor climate regulating

- High thermal mass with heat storing and moisture buffering capacity



Scaleable, dependable production

- Alternative to existing block production processes



Eivor Björkman Elementary

What this work intends to bring to the planning of Eivor Björkman Elementary is insight into the current building industry and the local perspective on earth building. The Gambia is a country in development, its development is occurring right now and it is particularly apparent in the area around the school plot.

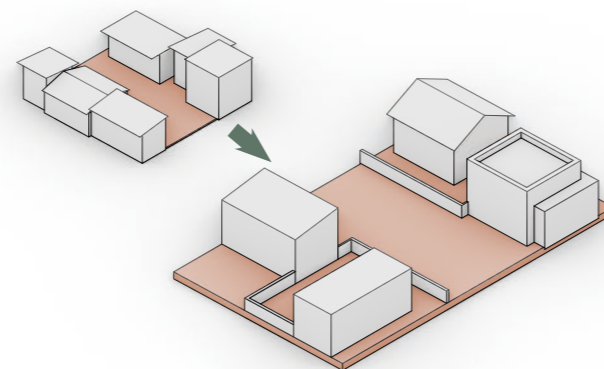
Old and temporary housing is knocked down to give room for new main roads. Single family homes and two-three story compounds take their place, and drainage systems are installed along the new roads to deal with the flooding issues. In this process, where old is replaced by new, traditional manual construction methods are left and replaced by more mechanical and industrial ones, offering scalability and dependability in production on another level.

Modern Gambian construction works in multiple steps: structures are raised through blocks, columns and beams are cast within, and all is refined, detailed and touched up with a finishing layer of plaster or tiles. In the rationality of this process, in an ongoing societal shift from old to new, earth needs to provide an alternative if it is to be a viable option in Gambian development.

The existing earth building industry is already proving that modernised construction that maintains a connection to the old and traditional is possible, but architect and engineer involvement is lacking. By initiating and inviting to conversation, held on their terms, our design and structural optimisation expertise can help Gambian earth building to develop even further.

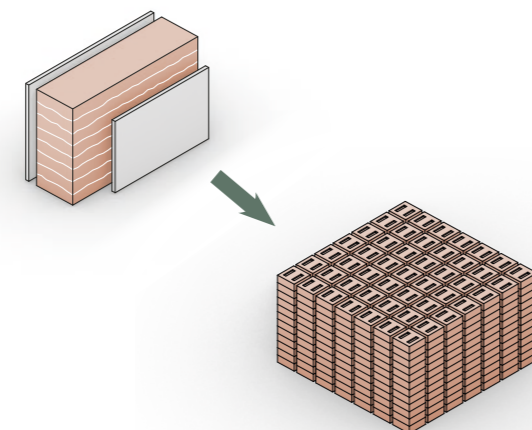
The area around the school plot in rapid development

- Old housing replaced by new, larger homes and multiple story compounds
- New road construction and infrastructure projects



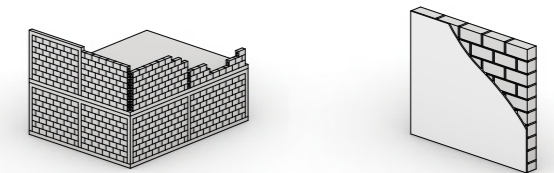
Shift from manual to industrial production methods

- Manual building methods replaced by more mechanical, scalable methods



Current construction processes

- Prevalent construction based on block, beam and column structures covered by fine layer



Pre-fabrication in development

- Relevance of pre-fabrication methods in Gambian development, as per the UN development programme, to reduce costs, waste and move employment from informal to formal sector



School location context





Initial design concept for Eivor Björkman Elementary re-imagined based on the state of the current Gambian earth building industry

Reflection

For me personally, my fascination and interest in earth building started by encountering rammed earth in Austria with Martin Rauch from Erden. The material represented a raw and elemental authenticity, a rudimentary and simple way to build with completely natural materials that would render uniform monolithic results. Furthermore, it represented a way to use an extremely low processed and fully circular building material in strive toward a sustainable construction sector, and is, due to its discard in development of industrial building processes and subsequent recent re-discovery today, full with potential for design exploration and to find ways of use in modern day construction. It is usually considered too labor intensive, expensive and unreliable to use in its traditional form of production in industrialised construction, yes, but in the context of a developing country the advantages could be large.

Based on this fascination, this project took its initial point of departure: exploring the potential and feasibility for rammed earth construction in The Gambia as a way to build sustainably, affordably and desirably with earth in a context where a huge amount of buildings are bound to be built in the imminent future.

What I found however, was that the prerequisites for and attitude towards earth building in The Gambia are quite different. Rammed earth as a raw and authentic natural material, and symbol for a low-tech and vernacular inspired future free from highly processed materials and complicated technical systems, as seen from my point of view, is rather seen as a method of old days where industrial processing was not possible: a state which the country and its population strives to develop from. This perspective was hard to grasp at first but made sense when eventually acquiring an understanding for the completely different contexts that The Gambia and Sweden are coming from and how that affects the view on development and strive for a better future - in Sweden we take technology for granted and sometimes would even blame it for causing the climate crisis, whereas in The Gambia it is seen as the solution to and a necessity for improved living conditions, end of poverty and an improved future. Furthermore, The Gambia is already in a semi-developed state, especially in

urban contexts, with a refined construction industry capable of producing multiple story residential and office buildings of up to six to eight floors or more. This is where the Compressed earth block comes in as an alternative between earth building and industrial processes, and it's the reason for why it has become the prevalent earth building method in The Gambia today. The block as a symbol of repetitiveness, monotony and industrial processes disconnected from human influence as initially seen from my point of view, instead constitutes the form of standardisation the current Gambian building industry is built on, and represents modernity and technological advancement. On top of that, it is an improvement of a traditional and vernacular method in the cultural context of The Gambia.

My process started with the intention to develop personal knowledge about earth building, spread this to local actors by developing and building a prototype together, that in turn would inform strategies for the design of a rammed earth school in The Gambia. By letting the Gambian context, interaction with the people as well as earth builders influence the process and the objectives, it turned into a project for finding what role a Swedish architect could fill in the existing Gambian earth building industry to bring new perspectives to develop it, how a collaborative design and build process with an earth builder could result in mutually beneficial knowledge exchange, and how this type of process can influence the design concept of a school building of earth in The Gambia. The initially acquired knowledge on earth building changed from being the main objective with the field studies, to acting as the foundation on which this mutual knowledge exchange was possible to build.

Results of the collaboration is a new way for Jallow to use his existing processes that could expand his market and increase the use of earth in construction in The Gambia. What I bring back to Sweden is practical knowledge about an earth building method adapted to industrial building processes, in a country where the use of compressed earth blocks is virtually non-existent: hands-on experience with material procurement, block production and construction. The process in

The Gambia is rather manual, and in Sweden there would be a lot of potential for increased efficiency by developing automated processes. However, as with all earth building methods, the importance of the right raw material can not be stressed enough, which proves the relevance of hands-on experience also with this method for good results.

The project can be seen as a prototype in itself of how a holistic architectural approach in the context of a Swedish aid work project in The Gambia can

provide new perspectives on earth building and lead to lasting values in both countries. It sets an example for how interdisciplinary collaboration across borders can invite and inspire to dialogue and conversation.

The conversation continues, in different forms and different contexts, but the central theme is the same: it's a conversation with Earth.





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