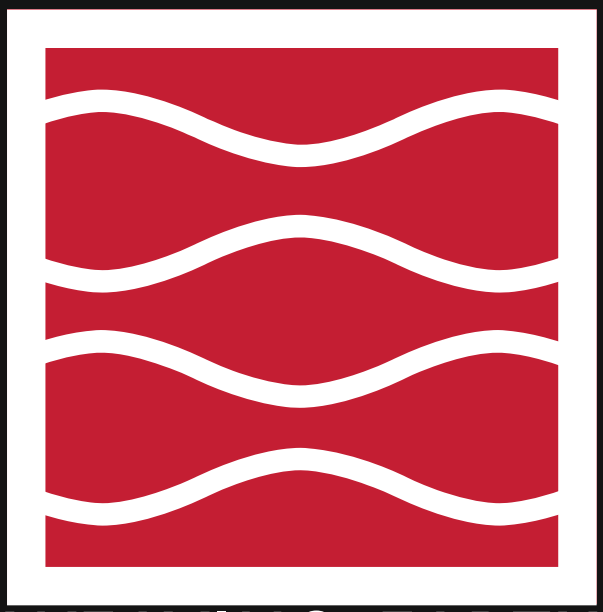

WEAVING EARTH

Acknowledgement

A big thanks to our tudors Shea, Catarina, in the unprecedented situation of the Covid-19, managed to keep us updated and organise our return home again, to the other Reality Studio students, Larry and Todd. To Evance, Apollo, the crew at Zingira and Steve who shared their experience and network. Finally, a big thanks to the staff at Sooper guest house.

This is a compilation of material from a project work within the course Reality Studios 22,5 credits, ARK496
Master programme Architecture and Planning Beyond Sustainability, Department of Architecture and Civil Engineering,
Chalmers Unviersity of Technology, 2020

Authors: Mats Andersson, Che Yu Liang
Examinator: Emilio Da Cruz Brandao
Tutors: Catarina Östlund, Course coordinator
Shea Hagy, Teacher

Abstract

The project is based om the field studies done in Kisumu Kenya during the spring of 2020 as part of Reality Studio at Chalmers University of Technology. The project have an ambition to try out earth building techniques, fusing Rammed Earth with traditional techniques within the local building stock and locally available resources, as a mean to get a few steps on the way to achieve a non-permanent material and construction with the same qualities as a permanent buildings. Mainly for where there is this legal issue, as in many informal settlements. But also because of the potential impact on social, economical and ecological aspects, by using and upgrading local low-value materials, in this case to try out and adding the fibers from the Lake Victoria Water Hyacinth as a stabiliser in the earth composition. But also having a low-cost method with stakeholders, use of resources and labour in a process that can keep the movement of money local, and achieve an earth construction Toolbox for Kisumu, composed by the knowledge, resources and people in Kisumu.

This was all when the Covid-19 pandemic erupted, resulting in the intended field studies were cut short and the project had to be adapted to a new reality.

Mats Andersson
Chalmers MPARC Architecture

Che Yu Liang
NTUT Architecture bachelor

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Introduction

Kisumu, the third biggest city in Kenya. Located next to Lake Victoria and relatively close to Uganda and Tanzania. The central part of the city has still some character of the British colonial past with vibrant pastel low rise Art Deco architecture. Current developments and chinese infrastructure projects within and around the city including a new port may change that character within the next years. A ring road envelopes the inner city and becomes a defining edge towards the informal settlements situated outside. Population size is hard to define, 500000 +- depending on source. The reason to this is a certain degree of flux, either by temporary traders/workers from neighbouring countries, or as we found out after the Corona situation erupted, many have a home village that they can be returned to.

Obunga, the major informal settlement in Kisumu. Being one of many in Kenya, it have it's own characteristics, possibilities and difficulties. Among one is the building code that stipulates non-permanent or semi-permanent constructions methods an materials, thus resulting in settlements that struggles to perform living conditions aligned with permanent residence. A previous Reality Studio project from 2018, Ram-up Obunga (Bührer & Kerboua, 2018), tried to answer this by applying Rammed earth as a continuation and to upvalue the local earth building techniques. This was formulated as a wall to the Emmaus Blessed School.

Lake Victoria, the Water Hyacinth, Dunga and Dunga Beach. The Water hyacinth, being an invasive plant originally from South America, appeared on Lake Victoria first in the 1980's (World Bank. 1996), and have since arrived seasonally as drifting islands, getting caught up and periodically covering the whole water surface of the Kisumu Homa bay. Bad news for the fishermen at Dunga Beach next to Kisumu, becoming unableto get their boats out of port and bad news for the women depending on the fish trade for their living. However these groups of women at Dunga also adapts by making craft out of the hyacinth. This got us thinking, would it be possible to add value to the material without the hours of work making handcraft out of it, but within the material itself and as such add an extra bonus income to these groups of women? The answer to the latter one turned out to be another group of women and a community involved with harvesting the hyacinth, some 50 km from Kisumu, however the first question still remained.

Zingira & Jua Kali.
In Dunga, just next to Kisumu, there is an ongoing Zingira and jua kali performed rammed earth house construction. Zingira being a community group in Kisumu, involved in projects of crafts, and an active part for involvement, change and improvement in the local area, have acted as a mediator and help between Chalmers and the various communities in Kisumu since 2005. The Jua Kali, roughly translated, " fierce sun" or "working under the hot sun", is a category of workers that Zingira has an aim to upvalue and improve the general attitude towards.

Considering method and technique. The Dunga rammed earth construction site uses an international widely used old chinese technique. An itch in the otherwise sustainable construction, was the use of cement, either as concrete blocks within the foundation, as lintels, or as a stabilizer in the very earth composition itself. Remembering from back home, the cellulose fiber embedded in the earth compositions of southern swedish traditional houses, a seed for a project formulation was born.

Projekt formulation

Could the fiber of the Water hyacinth act as a stabilizing fiber within the earth composition instead? The question evolved in to a negotiation if it's possible to compose a cheap rammed earth method and composition specific for Kisumu. The area already have other traditional earth building techniques. An earth building method for Kisumu could involve a fusion of the rammed earth method with heritage, tradition and existing earth building knowledge in the Kisumu area.

But it could also involve the social aspect of women business oppertuneties, a change of mindset for local methods and materials, local economy and low costs.

Kenya Vision 2030 The Big Four Agenda UN 17 Sustainable Development Goals

Kenya Vision 2030 and The big Four Agenda. Two out of these big four are the agendas of Affordable housing and Manufacturing. The project of Weaving Earth can be considered a merger between these two, whereas the end result have an aim of achieving affordable housing with the qualities and comfort of in this case permanent housing. It does so by considering the aspect of manufacturing or composition of construction materials that can overcome the legal challenge of building non-permanent or semi-permanent, while considering the economic aspect of being a cheap solution for the resident. The choice of what materials to include but also exclude is an aspect of an economic agenda, but also takes account for the environmental aspect the materials when building resilient and sustainable.

Considering the climate crisis, the building sector stands for approximately 39% of the greenhouse gases, whereas cement is a big part of the material aspect of these emissions (World Green Building Council, 2020). A reduction of this material is needed, but also from an economical point, being an external material contributing to money escaping the local economy. As opposed to this would be to upgrade local low value materials, using materials from local business and communities, to have the money used within a project to circulate within the local economy.

It is worth mentioning, that the project is not primarily targeting one specific of the 17 UN Sustainable Development Goals, but aims to achieve a holistic sustainable solution that will have more or less relevance to certain range of goals.

In Kisumu there is a limitation of resources, but on the other way around, an engagement in using what resources are available and upcycle material that would be considered waste in other parts of the world. The potensial in how the local material and resources are valued and considered could turn Kisumu to next to self sustaining with materials that are environmentally sustainable, both from a global and local perspective. However, some materials and traditions have either become stigmatised by colonial past or coming out of fashion and become replaced by commonly used industrialised materials and methods, for example cement.

The project thereby touches a range of sustainable development goals but without individual focus, by taking off from manufacturing it goes from 12. Responsible consumption and production, 13. the climate crisis on one hand, and on the other hand in a range indirect or direct affecting 11. Sustainable Cities and Communities, to the economic aspects of 8. Decent Work and Economic growth, 5. Gender equality, by considering empowerment of women by women history or adding business opportunities for women, to the economical aspects within 10. Reduces inequalities, to 1. No Poverty.

Earth Simplified

Rammed earth, the technique of compressing earth to a dense mass will be mentioned a lot in this booklet, however building with earth is an old and globally wide phenomena.

Variations of fiber usage

The Great Wall of China, rammed earth on layers of papyrus fiber. Main and the early technique used for the wall

Rammed Earth China


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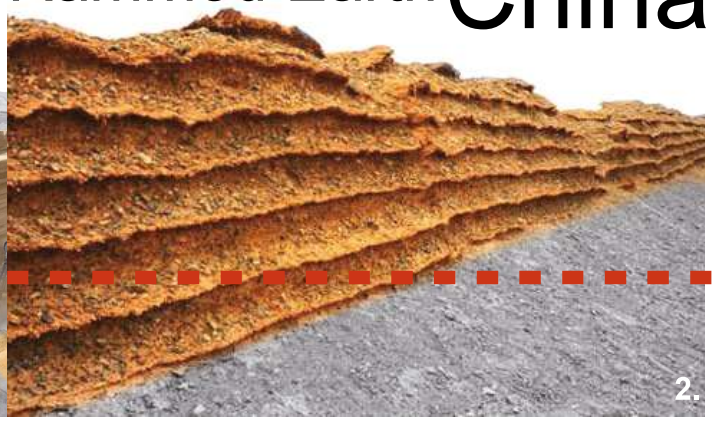
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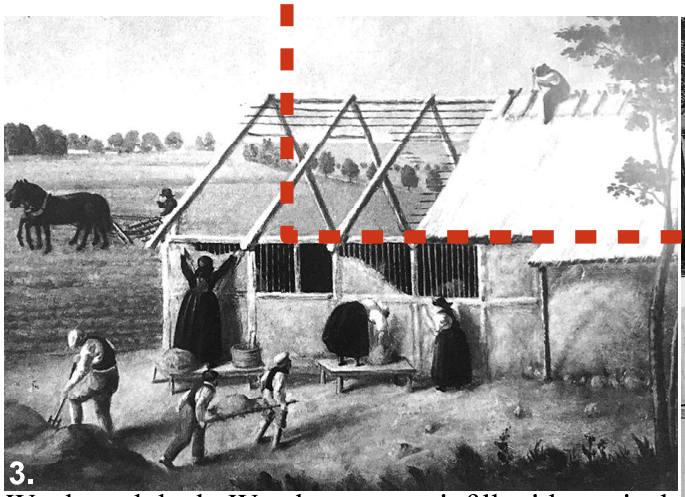

3.

Wattle and daub. Wood structure, infill with vertical slender wooden elements. Cladding with a mix of straw fiber, cow dung and clay. 19th century.


4.


5.

Southern Sweden Traditional Eart

Austria

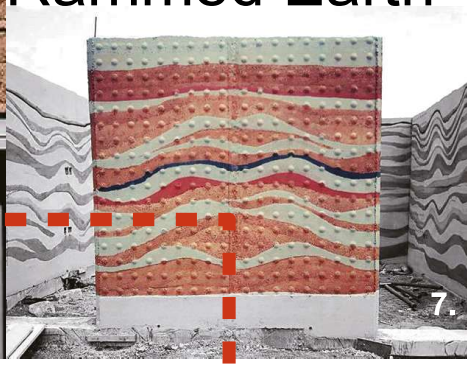
Martin Rauch, Roger Boltshauser, 2008

Mannerism in methods

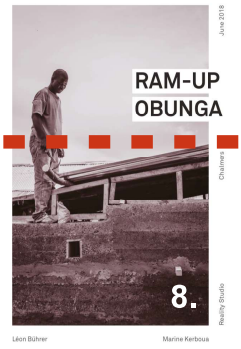
Ghana

Hive Earth, 2016

Rammed Earth



Rammed Earth

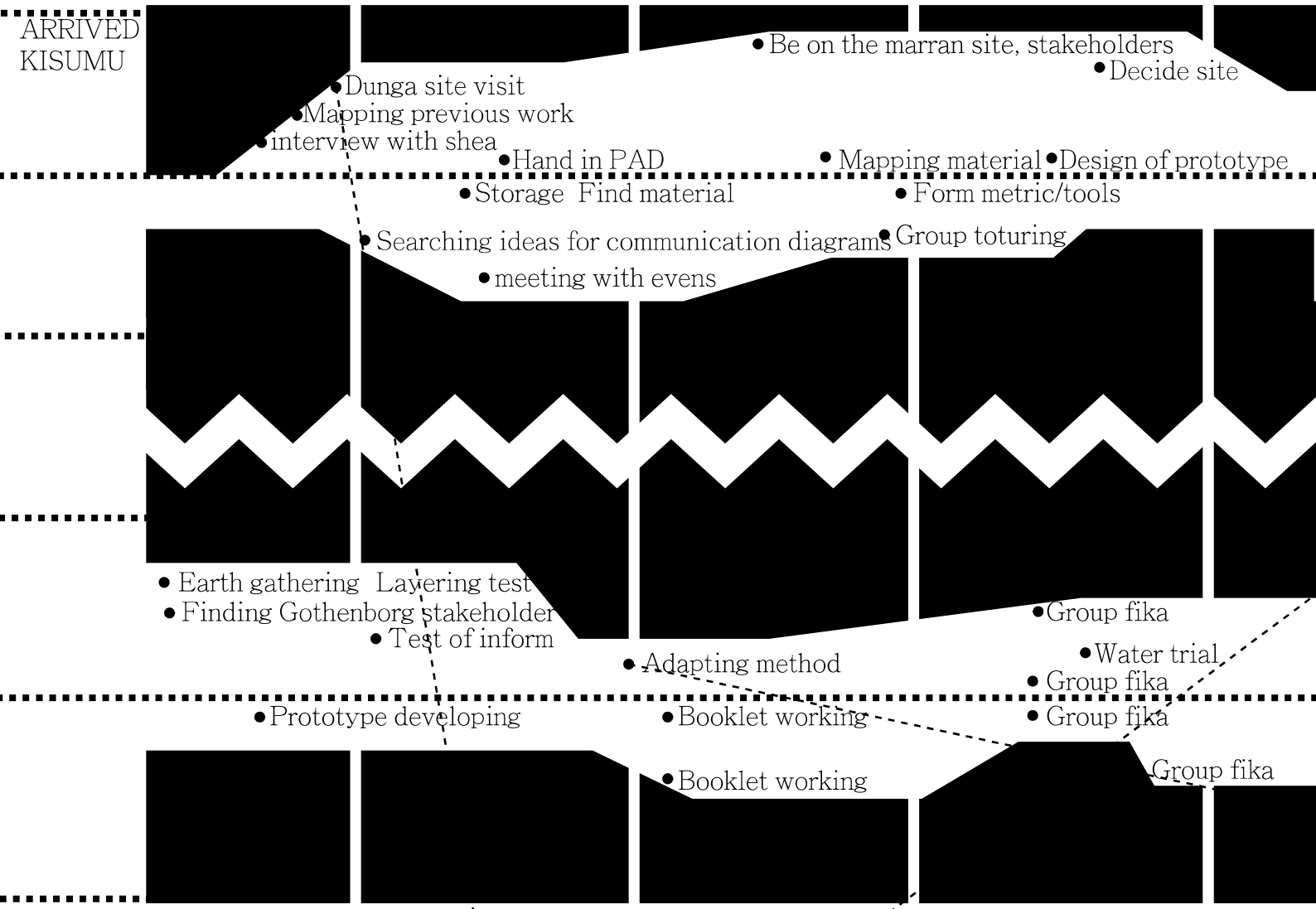


Emmaus Blessed School, Obunga, 2018. Co-creation: *Emmaus Blessed School, Jua Kali, Zingira and Reality Studio*
Residential housing, Dunga, 2020. *Jua Kali and Zingira*

th Buildings Kisumu Kenya

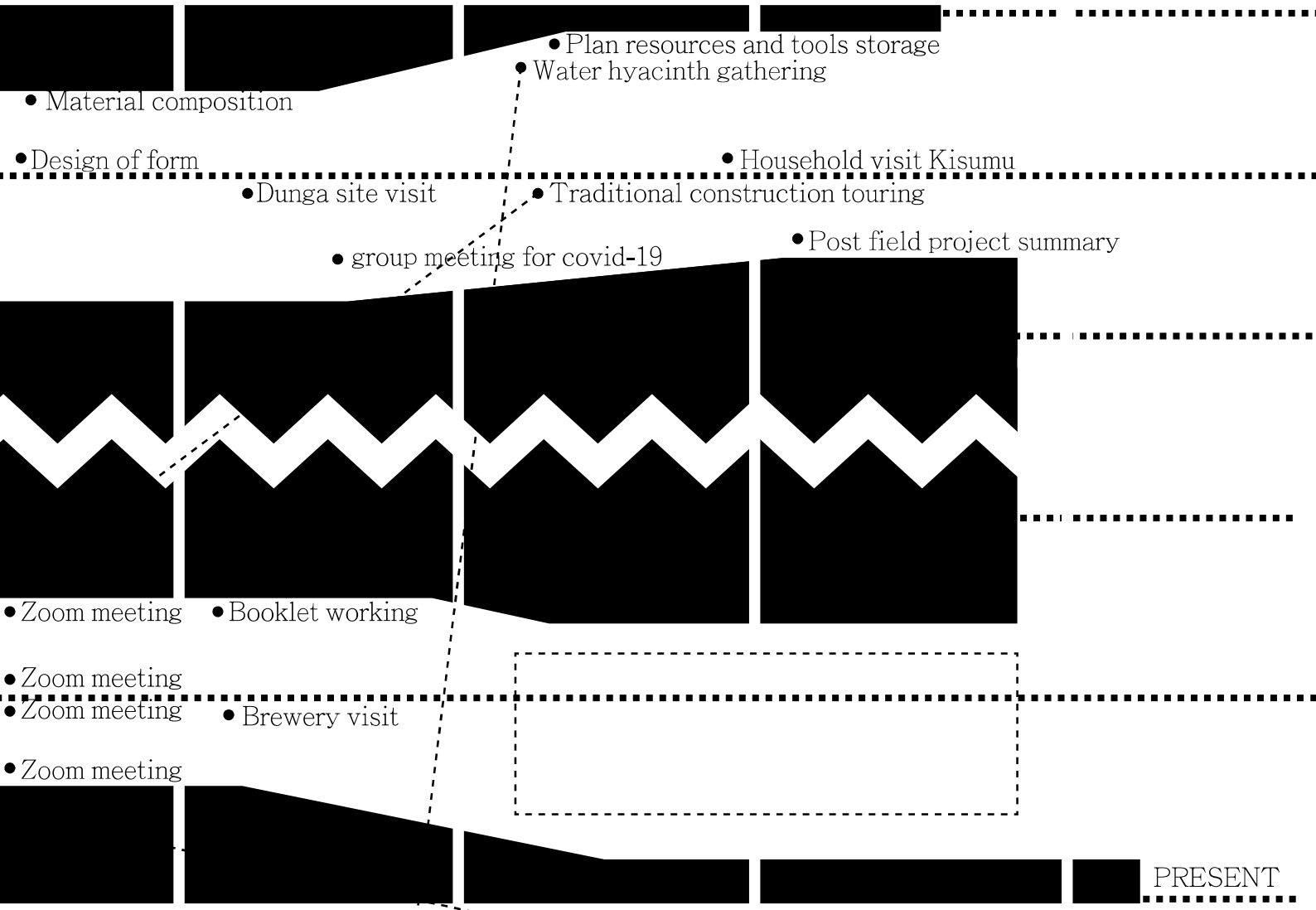
Traditional building with wattle and daub in Kisumu. Wood structure, infill with horrisontal slender wooden elements. Cladding with a mix of rocks, cow dung and clay.

Project Journey



Key words Site visit Dunga Zingira
Zingira, Steve
Rammed Earth construction
The existing formwork, heavy, difficult corners
Work procedure, heavy procedures, daily progress
The earth composition, cement and marram
Price for the components

Key words Site visit traditional building
Short life span
Wattle and daub, wood structure, infil rocks and clay mix
Ongoing process, maintaining or decaying
Modern clash of material, cememt, clay and wood
Wood and thermites



Key words SangoRota Kong'ou, Water Hyacith
Sesonal harvesting, persue off shore and at shore
Involved community members, 27 women, 3 men
Procedure, harvest, seperation, drying, soap treatment, 2nd drying
Products, thin ropes, for Dunga and Zingira
Hyacinth craft
Alternative use, Fiberboard?
Local available clay, brick use

Key words Adapting the project
Upgrading Low-value material,
Fish scales as a future project?
Rescaling and reformulating the project due to Corona
Going from compressing a large prototype to samples and ideas, to inflating them back to big ideas and prototypes

Information mapping

Site visits to the Zingira rammed earth construction site in Dunga.

During our first visits back to Dunga after the formulation of the project, we interviewed the main Jua kali on site, Steve, to get an understanding of the cost of the various materials and formwork, the requirements and conditions he had experienced so far with this technique. Steve had also been involved in the previous Reality studio project of Ram-up Obunga.

The formwork, having an economical usage of material, using the constraints, no more, no less, out of a single 1" 1220mmx2440mm Marine board, but also came with some challenges. Mainly size and weight, but also the placement of the rods keeping the sides together. The weight turned it in to a time consuming process, allocating 40-60 min just to move the formwork. The rods intersecting the layers demanded ramming around them, compromising time, and quality of the ramming itself. Due to the need to let free the sides perpendicular to the wall, not damaging the layers and corners, this procedure became heavy and the corners still proved tricky to keep intact. A part solution would be to install small 45 degree wood pieces to the formwork when making the corners.

Daily progress amounted to on average 10 cm in total height progress. This being an average since the formwork is stationary till it have progressed to about 45cm. Divided within three rammed layers, each layer being rammed from about 25cm uncompressed to being rammed to a 15cm compressed layer, becoming about 45cm in total.

The earth composition, containing 90% Marram, 5% cement, 5% water, with the cement varying depending on place of the building, but with extra focus on the foundation and then gradually decreased amount towards the top. The same with the corners, where the cement usage amounted to about 7%. Marram, being the main component of the earth composition is a local sandy earth with some clay content. An analysis from a Marram sample we brought back to Sweden, suggested the content of the Marram to be 10% clay and silt, 30% sand, 60% gravel. However depending on where the Marram is picked, the amount of the various particle content might differ.

Price for material might differ depending on situation, but a 50kg bag of cement in Kisumu would cost about 620KSh, replacing it with a bag of 50kg lime, would cost about 500-740KSh.

Site visit to traditional housing in Dunga.

On our third day we did a visit in company with Steve to the homestead of Maria, for a visit of traditional buildings. None of them in any significant age, the oldest of the houses being about forty years old. However a long time span is not expected by these kind of buildings. All of them in wattle and daub technique but in different states since time and circumstances had affected them differently. All of the houses had a main structure of slender wooden poles with infill of rocks and clay.

The house of the late father, had a treating plaster that required new or added plaster every one to two years, an ongoing process that was performed by the old father when he was still alive. This plaster containing fine clay found close to the beachsides of Dunga mixed with cow dung, still with small fibers visible in the surface. The plaster had long since begun decaying after the death of the old man, and the surface closest to ground and most exposed to the rain had fragmented, vanished and left the inner content of the walls fully exposed.

The house of the still living old mother had got a recently cement based plastering. Presumably in good conditions for now, but a combination of material and techniques that instead of small manageable continuous maintenance requirements, have the risk of bigger more sudden setbacks. This since the combination of wood and clay on one side, and cement on the other have different behaviour in terms of flexibility, movement, and how the cope with moisture.

The house of Maria, similar to the old fathers house, but exposing the problem of part wooden structures in a land also residing thermites. This came to show in one of the walls that had been thermite stricken, lost it wooden structure and subsequently collapsed and being renewed again. The thermites not being satisfied yet, had since begun their year long endeavor of devouring the wooden roof structure.

Site visit to SangoRota Kong'ou

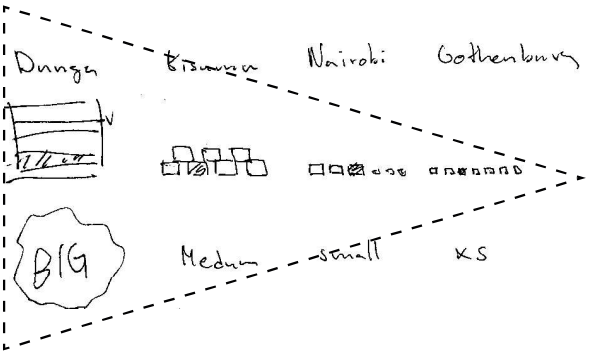
On our fourth day, guided by Apollo from Zingira, we squeezed ourselves in to a Matatu for the source of harvesting the Water Hyacinths. Our destination, SangoRota Kong'ou, a fishing community some 50km outside Kisumu. Where 27 of the women and 3 of the men of this community are involved in the trade and craft of the Water hyacinth. The trade of hyacinth is the only work these women do, a seasonal occupation, and they are thereby not simply waiting for the hyacinth to arrive, but also pursue it by boat when it is still far off shore.

Procedure. The hyacinth is cut off or picked and gathered from the water, leaves are cut and removed from the stem, while the stems are cut in two lenghtwise and then left to dry in the sun. The stems are then treated with soap (Sodium metabisulphite) and left to dry a second time. As a final touch by this community, the fibers are woven into thin ropes, a production that in a month generates some 2000 thin 15m long ropes. These ropes are then what becomes the basis for the hyacinth craft by the women in Dunga beach and the craft by Zingira.

The fiber as a rough construction material, corresponded an idea from one of the community members involved that it would be interesting to explore the possibilities of making an alternative to gypsum boards made by the fiber, what we imagine would be a sort of "water hyacinth fiber board".

Other available material. On our way back we noticed a local brick furnace, being an area rich on clay, this local communities go-to material earth building technique was that of the brick and it dawned on us that most of the buildings here contained this bright orange local brick.

Price material: 90kg bag of dried fiber: 2000 KSh (3 ton of wall material, if fiber content is 0,3% of the total weight).

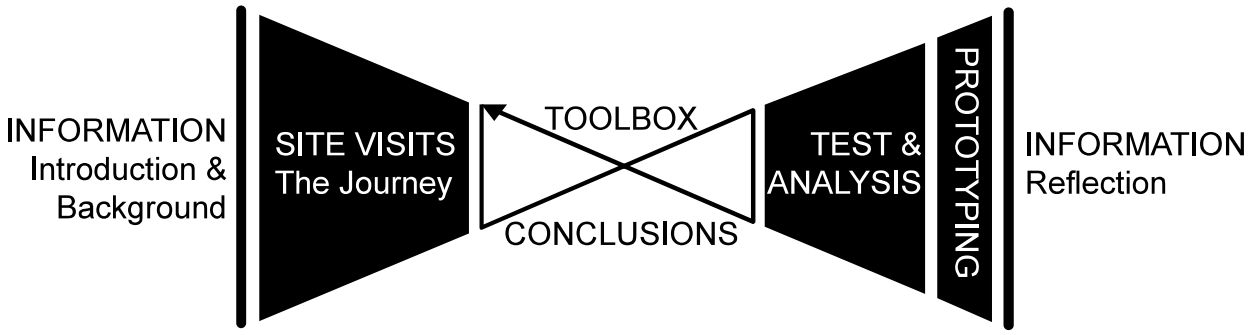


Adapting to Reality.

One idea that we didn't have time to explore, was a perhaps crazy one, but we figured relevant enough to be mentioned for future ideas. This was that of the fish scales. Fish scales being the last left over material in all the treating of fish and considered worthless and being burnt in small piles. In this line of work, it ended with groups of women earning the least out of everyone involved with the fish trade. But the same question emerged here, could we find a use and value for a non-value material without or with minor work input, benefitting these groups of women? Fish scales, consisting of emalgie and calcium, could it be some sort of lime substitute within an earth composition or clay plaster? Within our scheduling we kept this away from the first week before we knew what was manageable within our timespan in Kisumu.

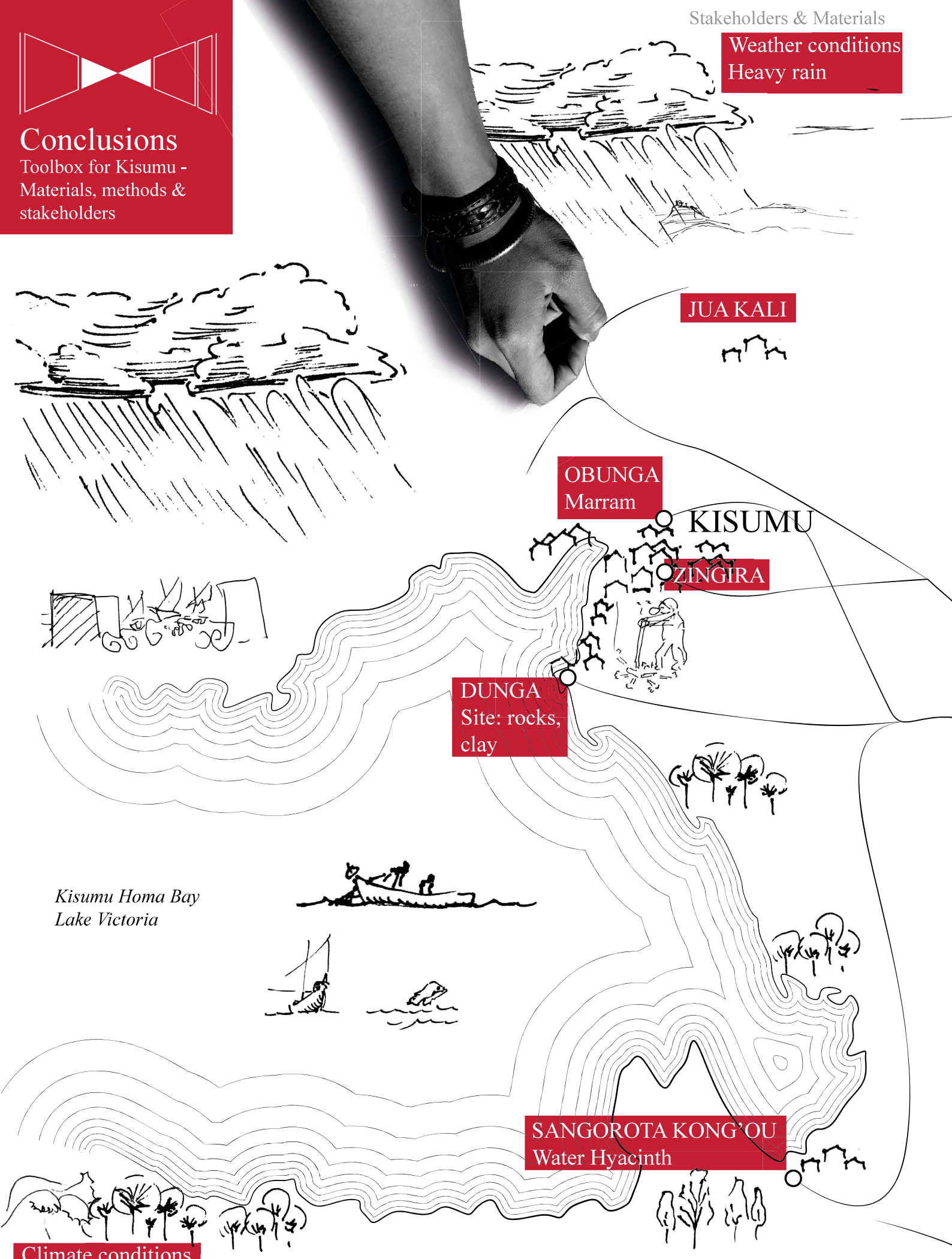
Then Corona happened, or it had by some time, but now the shit really hit the fan, and we had to leave.

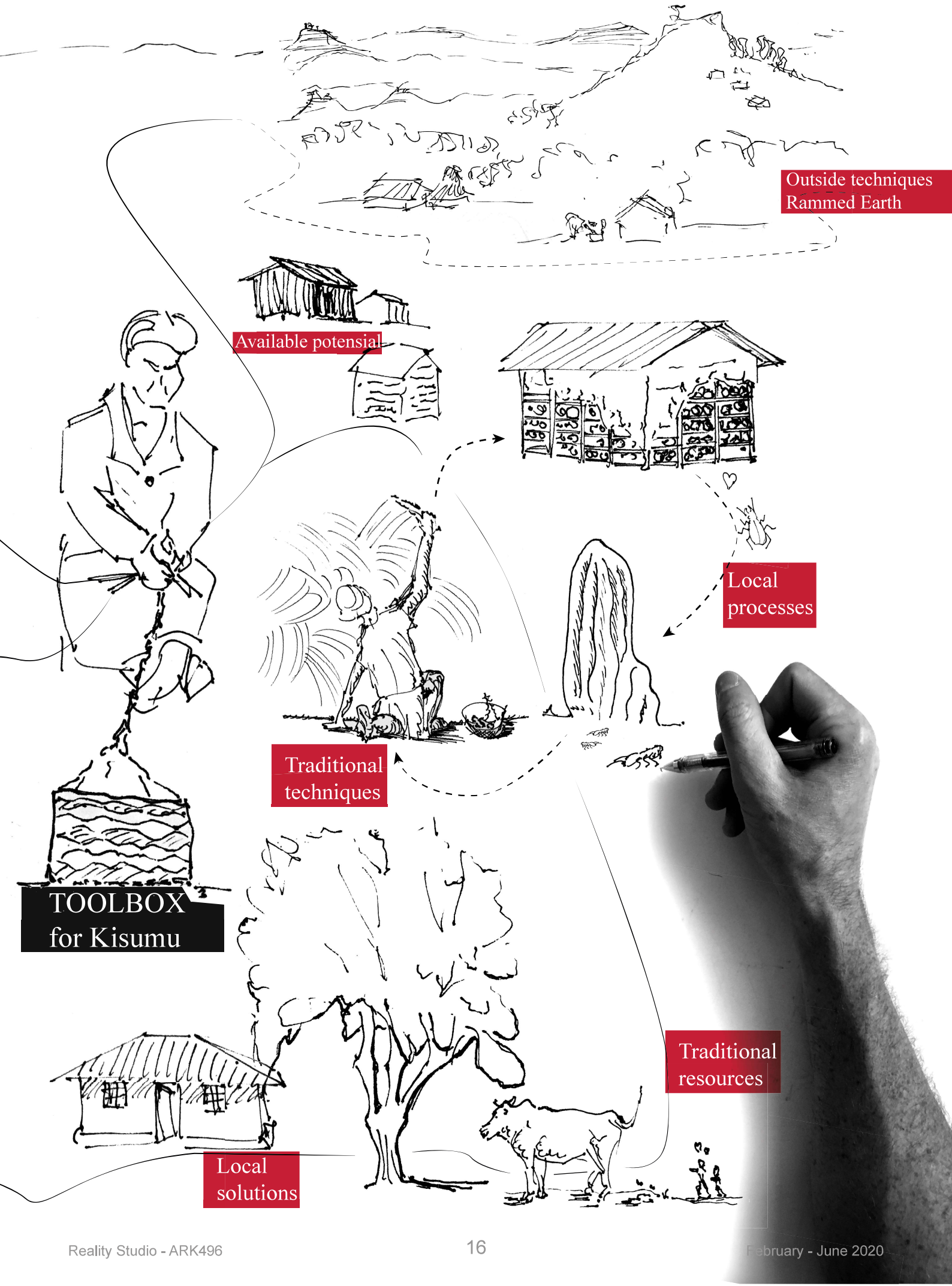
We had by this stage intended a L, M, S, XS, approach of display and representing the material, the biggest impact being the Site in Dunga, Medium samples for the presentation in Kisumu, Small ones for the presentation at Kenyatta University in Nairobi and finally very small samples back to Sweden. Our solution became to turn it all around, bringing small samples back to Sweden, and there unfolding the project in bigger steps. During Our last days we collected clay within reach from the Dunga construction site and Marram from the construction site. The visit to where the Marram is sourced next outside Obunga, was a site visit we intended, but missed out on. Dried Water Hyacinth we got by one of the ladies involved in the Hyacinth craft on Dunga Beach. Next followed our journey back to Sweden, 14 days of self quarantine and a project that had to find ways to become adapted to the new circumstances.



Conclusions

Toolbox for Kisumu - Materials, methods & stakeholders




Outside techniques
Rammed Earth
Available potensial
Local processes
Traditional techniques
TOOLBOX for Kisumu
Traditional resources
Local solutions

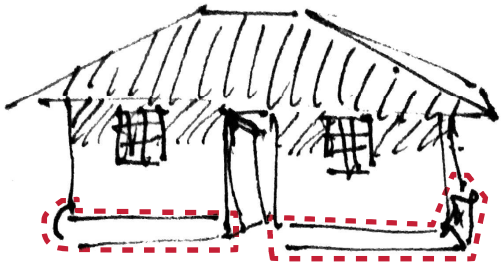
Toolbox for Kisumu

Recources - *locally available, low-value, stakeholders.*
Economy- *Cost & local ecomomy*
Existing knowledge and traditions
Concetpual methods & solutions

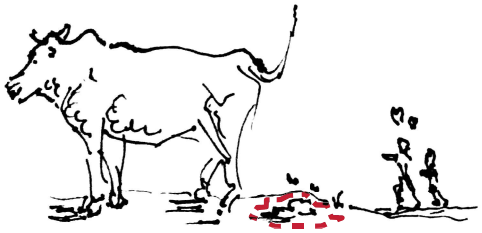
Traditional & existing methods

Earth building tradition in the Kisumu context

Traditional earth building techniques in Dunga and Kisumu, usually involves a thin wooden structure that is covered by a combination of rough earth material, cow dung, and rocks, and finally plastered by fine clay/cow dung plaster. On some buildings a great base bold is a visible feature. The function is a practical one, by sealing off the base with more material protecting it from the rain. It is also a social one, providing a place to sit down, protected in the shade from the often extruded roof eaves.

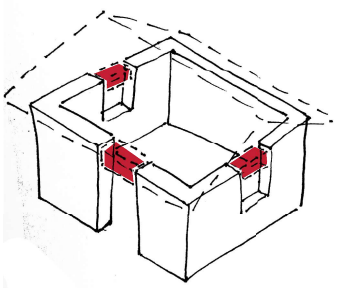


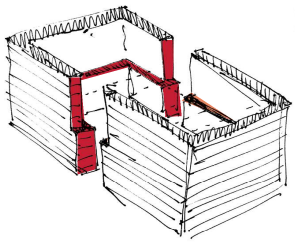
Cow dung, fresh, as a component in either plaster, by mixing it with clay, typically a fine white clay found near the lakeside of Lake Victoria, or by mixing it with routhger earth material and rocks from the site in Dunga for the wall construction itself. As a material cow dung have traditionally been available to use freely when there was the need for it, belonging to everyone, regardless if it came from the own family cow or from a neighbouring village.

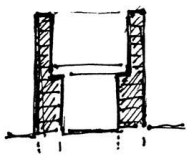


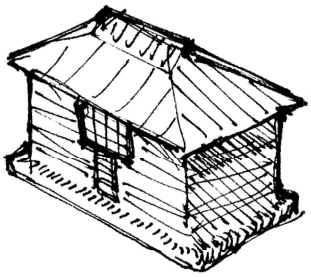
The wooden structures are usually not to last, since it is also appreciated by termites. From the first sign of attack it usually takes a year for the structure to be absorbed by the termites. The walls then either sets slowly, slightly altered and deformed, or if unlucky, collapses. However, this scavenge for material isn't one directional. The termite nests are made of fine material, making the nests desired as a source of material for plastering. A sign of possible ecological change can be seen in termite nests used to be more common in the Dunga area. However, termites can travel for many kilometers, so wooden structures are still being plagued, but more likely from far away colonies.

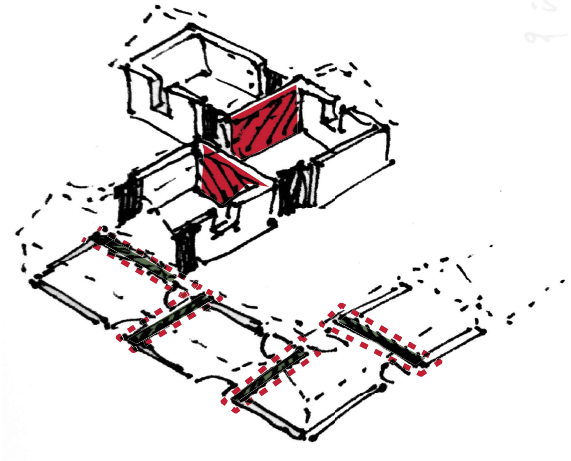
Toolbox - Concepts for Kisumu











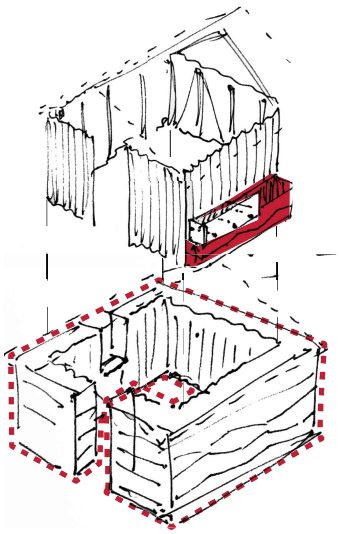
"Lintels are Lava". Since lintels only supporting themselves would require cement or concrete, thus being a questionable extra cost. A cheap and simple solution would be to simply avoid them in any openings, and instead fill out with windows/doors/ upwards or with simple cheap and light materials.

In a two-story situation, as in the current site in Dunga, a solution without concrete lintels, could be specified in a design with a thicker first floor walls with a thinner upper story walls, providing a horizontal surface for extra fixture of the flooring. Windows on the upper floor would be located straight on top of any openings on the first floor. Any infill not being a part of the door or the windows would be made out of light materials.

A conceptualisation for this would be a
Dunga principle concept
A Two-story no-cement "Lintels are lava" situation, and a no concrete bulb foundation made out of rocks from the site.

"The Medina". With inspiration from urban planning in some traditional islamic settlements. The idea is when constructing a home, one wall is designated for a future neighbour. The outcome and idea is simple, you end up building three walls instead of four. Cost and construction for foundations and walls are thus reduced by 25%. An idea when considering rammed earth with this concept would be to start the next building with a gap, using these gaps for doors and windows, and thus not risking any damage to existing structure during the construction.

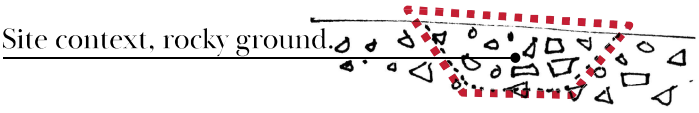
"The Mexican Larry". A combination of an Earthlab method used in Mexico and our professor Larry's proposal to use metal sheeting as formwork. By simply using an existing metal sheet structure as the formwork's inner surface and thereafter ramming earth on the outside of the structure using a single sided mobile formwork surface for the exterior. Excess metal sheeting after the construction could either be used for an extra inner roof, allowing an extra layers of air to reduce the heat inside the building, or be sold on and improve the economy of the project.

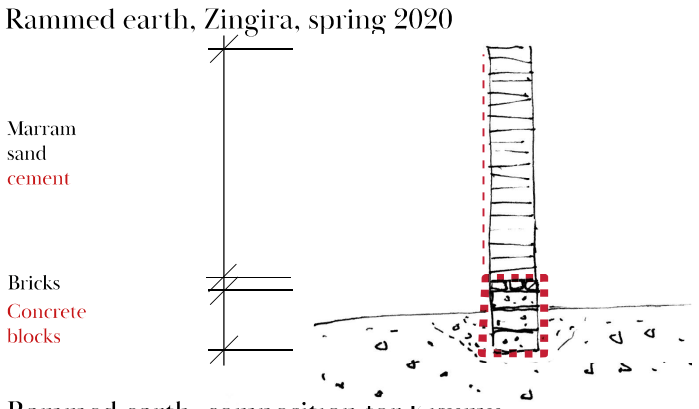


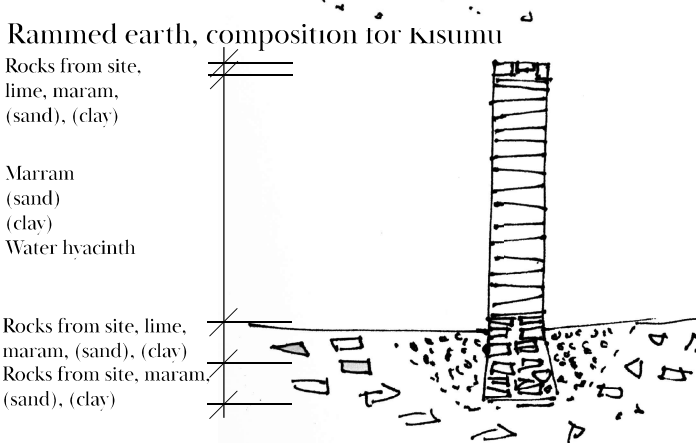
Toolbox - Fusion of methods

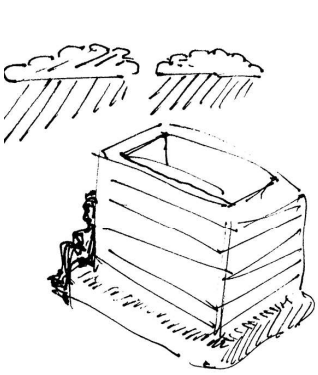
A lesson from previous projects, the cost of the foundation, for example in ”Ram up Obunga”, the estimate cost for for the foundation amounted to almost two thirds of the total material cost.

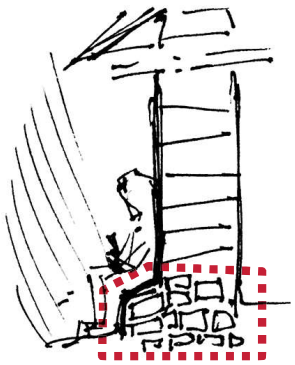
The material, fiber as earth stabiliser and a rocks from the site as a foundation, can become a good combination for costs and material charachteristics. Being many stone pieces, the foundation won’t act as one solid piece, and will have the possible side effect that by time it might adjust and set itself. The idea of a fiber as a stabiliser instead of cement, means that it will remain a flexible connection within the construction that follows and adjusts small movements better than that of the firm cement based construction. Cement based would risk give away in bigger fractures and cracks under those circumstances. The same would go for a composition of to high clay content, as an existing school north of Kisumu became an example of.







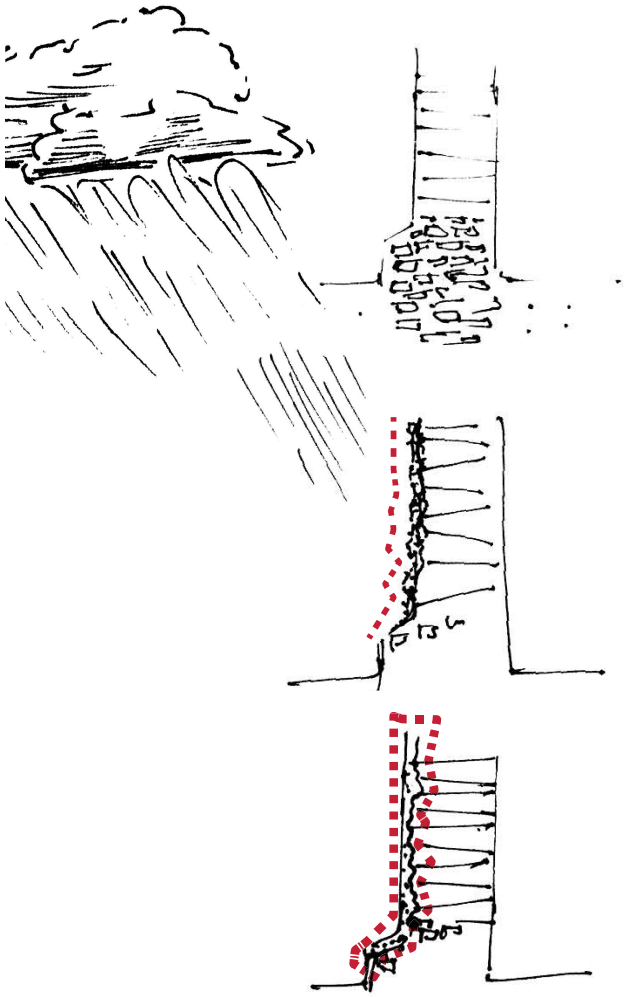




The soft goes first, consequently avoiding a foundation that is ”stronger” than the overall wall, as would be the case with a contrete foundation might also help spare the bottom part of the wall.

The site in Dunga, in an area with conditions such as seasonal and lately random floodings, as well as the seasonally heavy rain. A solution against this could be via a fusion between the bulb from traditional housing with the rammed earth, making the most critical part of any walls, the foundation, having extra material and safety from rain. This would also compensate the rammed earth’s inability of being repaired by more material, by adding a piece that can be maintained and replastered without or very little structural compromise.

Toolbox - Fusion of methods



Surface treatment
A way of treating a rammed earth construction to withstand weather, is to treat the surface with linseed oil. The oil is then absorbed into the surface where it hardens, creating a protective outer layer.

However, there might be other purposeful ways. The cow dung and clay plaster used in traditional buildings could be a consideration. The cons of it fracturing and peeling of the on flexing and lively construction of the wattle and and daub constructions might be less of a problem on a rigid rammed earth construction. Alternatively the plaster would be made of clay and lime, with the cost and use of lime would only effect a thin layer of the wall instead of the whole mass of the wall itself.

Initially when made, the rammed earth surface is relatively flat and a plaster would struggle to properly attach. But if letting some spray of water hit the surface, the surface would come out rough. If the earth composition contains fibers, say Water Hyacinth, these fibers would in combination with the rough surface add extra texture for a plaster to attach.

"A woman's work". Within an interview with Steve, the process of plastering and decorating the plaster was revealed to us. A process by making patterns from Aloe vera or used and dried corn cobs. Traditionally a womens job, but nowadays a part of a process becoming rarer with the introduction of cement based plastering.

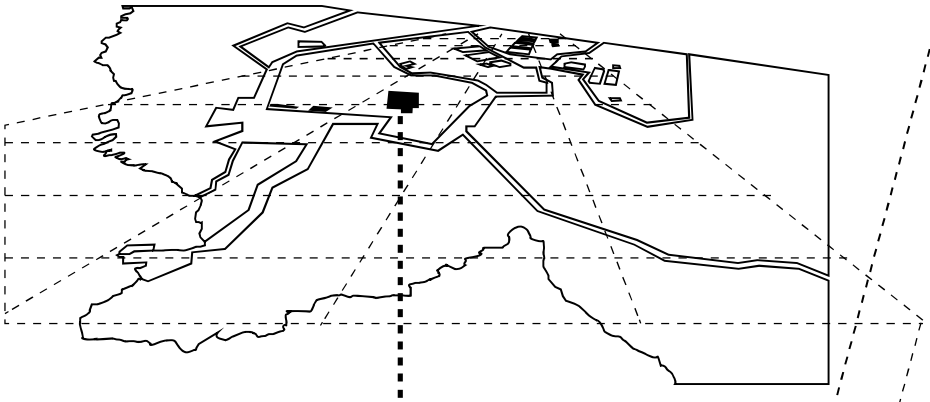
Analysis & test

Test 4/15 Test 4/27

Ringön/Gothenburg/Sweden, Earthlab

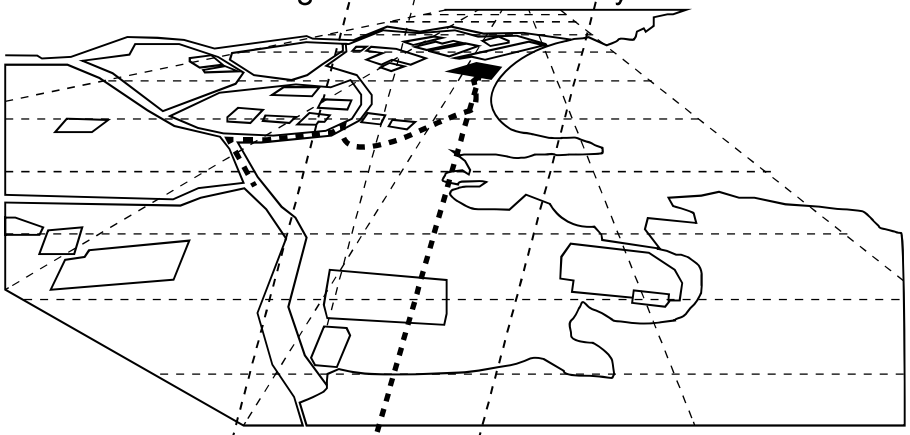
ecological torism concept

Dunga/Kisumu/Kenya



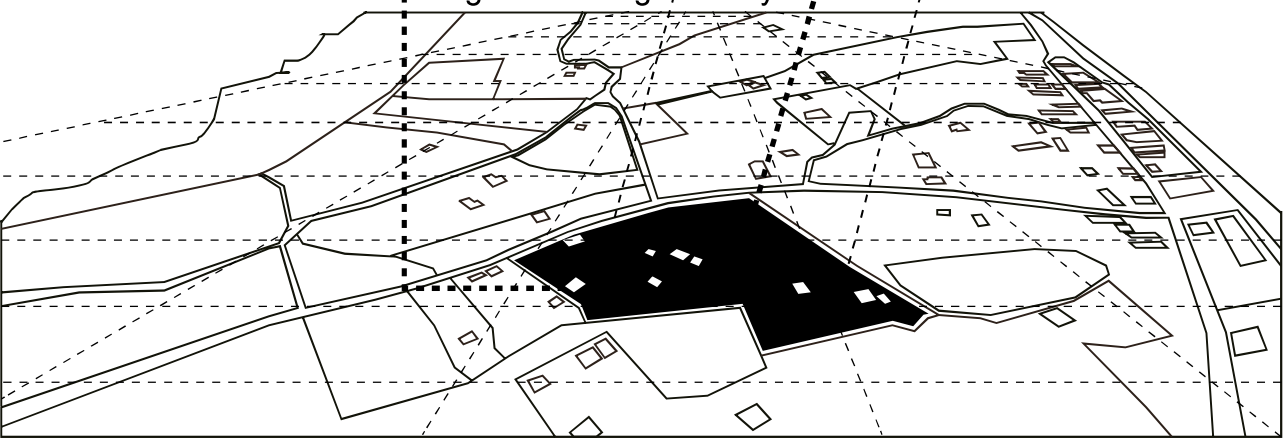
Construction site/ steve

Dunga Beach/Kisumu/Kenya

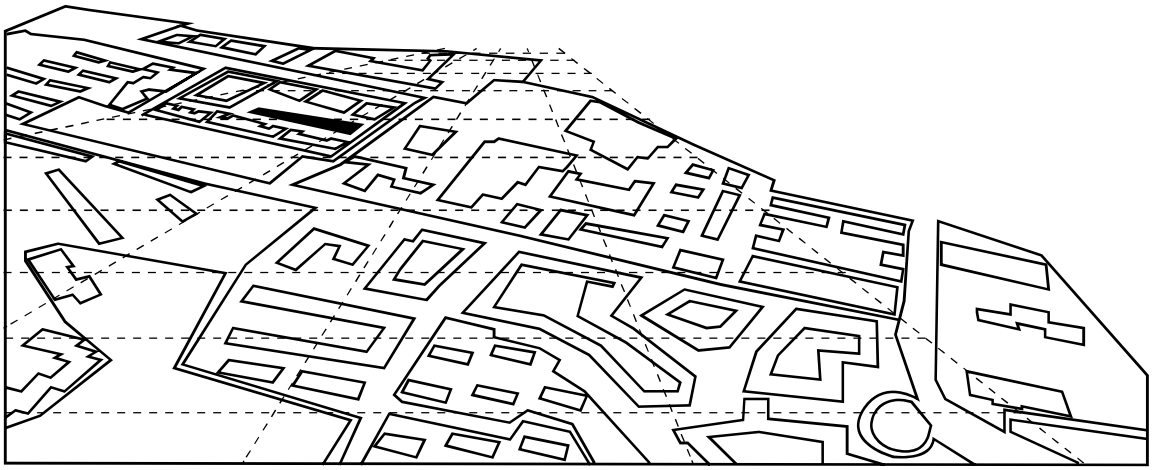


Hyscinth

SangoRota Kong'ou/Kenya



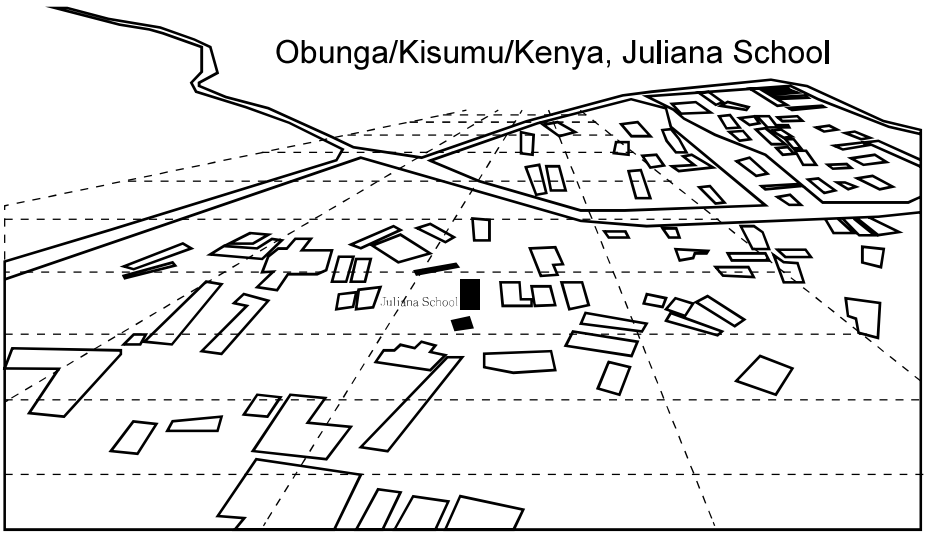
Gothenburg/Sweden, Chalmers



chalmers

Idea mapping and mapping, from Kenya - Sweden - and back again

Obunga/Kisumu/Kenya, Juliana School



"Searching and identifying stakeholders is one hard and time-comsuming process, the mapping of these information really helps us a lot, buy clarifying different intention we have both in economic and transportation, we have been more aware of the most fundamental part in our project. Which is the budget, and the time.

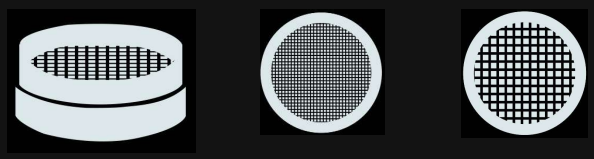
Communication is the crucial part as well, thus different stakeholders doesnt really assciate with each other, we have to filled up the whole and gathering all the puzzles, and it often takes long time to do it. The experience we have learned, was never doing something really needs for someones help. The time of waiting will more or less take your time of developing the project." -Liang

Analysis

Kisumu Material
Gothenburg
15/4 2020

Household experiment

SIEVING



BLEND

RAM

Analysis and test of the marram earth sample brought from Kisumu.

Analysis. Sieving and separating the fine particles of clay and silt, from the bigger particles of sand, medium sized sand and gravel. The proportion in weight amounted to 9,1% silt and clay, 28,2% sand and 62,7% gravel. On average the content of clay and silt 10%, sand 30% and gravel 60%.

For the variations of test samples we didn't change the composition when adding the particles back together, but kept the original proportions, but with the addition of about 15% water.

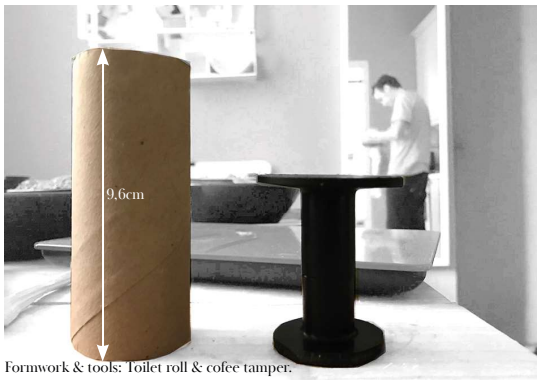
For the fibre test sample, we added the water hyacinth fibre. Conclusions from reference research projects about adding fiber to rammed earth, found an optimal fiber size to about maximum 16mm, and amounting for about 0,3% of the total weight (Simenson, 2011, page 14). Since Water hyacinth doesn't have straight fibers, but tangled ones, we went for a maximum length of 10mm when cutting the hyacinth fiber.
Due to the limitations of the scales we were using, we estimate the weight of the fibers to have been about 0,5% -+0,2% of the total weight.

The drop test being just dropping a good as possible ball af the sample to the ground.The unaltered marram became a fragile mix, that scattered widely.
When adding the fiber to the Marran the result was quite immediate, the marram quickly became a workable ball, and when dropped, except for a small fractured piece it didn't scatter and kept its shape.

Finally for this session, the material samples were stamped in to a toilet paper roll and left to dry. These samples were to be tested later in terms of strengths towards stress and pressure.

Analysis & Test 15 /4

Marram composition (tot: 3414g)



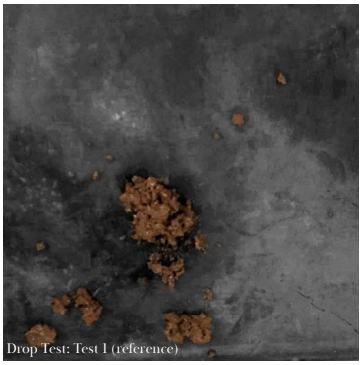
Formwork & tools: Toilet roll & cofee tamper.


Water Hyacinth: Fiber separation by hand


Water Hyacinth:
Ffiber separation by blender

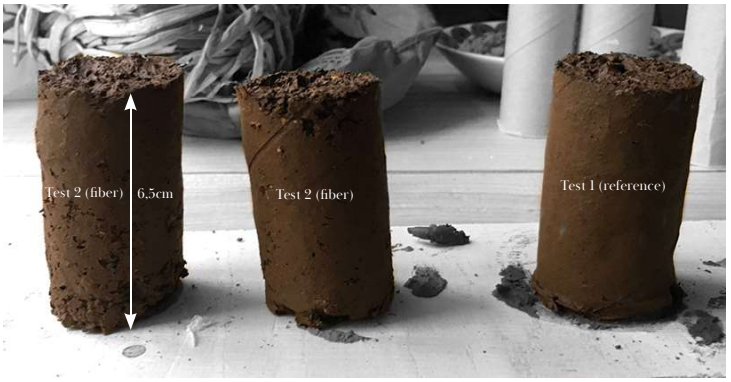

Water Hyacinth fiber.


Blending. Test 1: just marram with water. Test 2: with addition of water and fiber.


Drop Test: Test 1 (reference)


Drop Test: Test 2 (fiber)


Stamping (tamping) of material in forms



Test - Weaving Earth

Gothenburg
Earthlab
24/4 2020

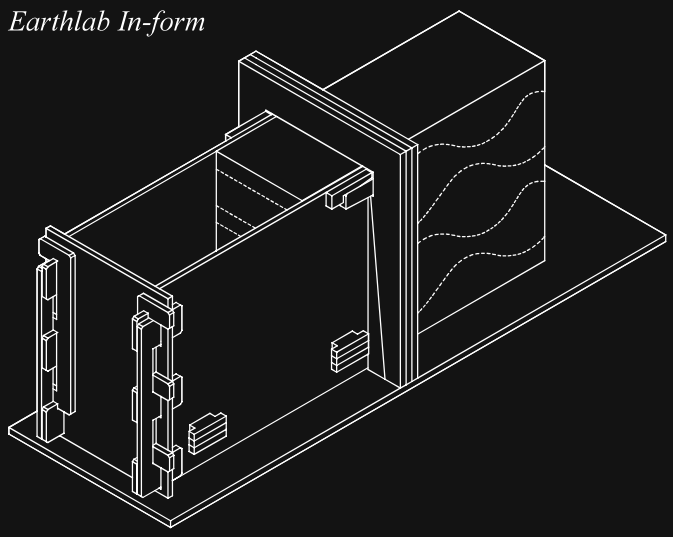
The Formwork.
A conclusion from the site visits in Dunga, was that the formwork was hard to work with. One thing was therefor to try out the lightweight concept with no rods developed by Earthlab. A formwork consisting out of only CNC cuttable wooden parts (Earthlab, 2020).

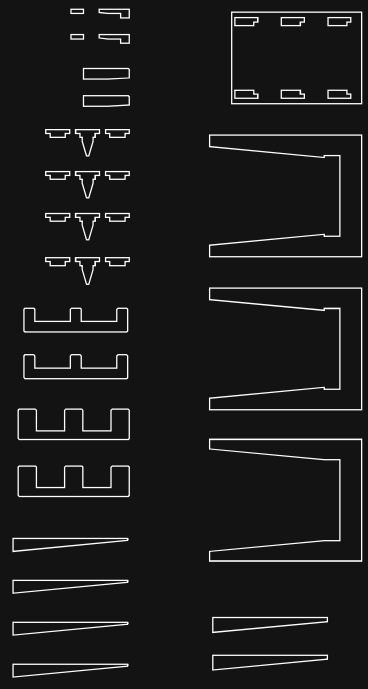
Weaving Earth
Weaving earth is a method concept we came up with during our time in Kisumu. When applying a layer of earth and then ram it, the earth closest to the top becomes more compressed than the earth to the bottom. Our idea was to ”join” the compressed part of each layer to each other to become a compressed earth weave.

The reasoning behind this method is part to discover the poethics and characteristics of the material. The other aspect is that it may fulfill an important design criteria when working with economy as a factor, as the case in Kisumu. It begins with the foundation, either it is made by one stiff solid piece, or a chain of many small pieces. The first one is more expensive, the latter one may adjust and settle over time. In Kisumu we opted for the latter one, due to being cheaper, the material is more available and the combination with the fiber stabilizer can perform a better flexibility than the stiff particle counterpart.

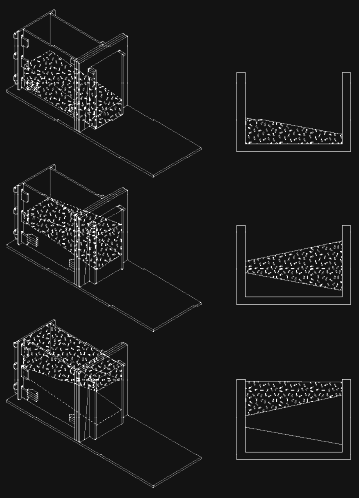
The weav could thereby come in to action if parts of the foundation encounters displacement. Normally with homogeneous straight layers the forces would go straight through the layers, making a short distance of friction within the material keeping the mass together. However since the forces going through a material takes the shortest route by the weakest parts of the material, a weave could complicate this route and add extra distance of friction keeping the material together. A likely outcome would be a big fracture in the straight layers, and many smaller fractures in the woven layers.

Earthlab In-form





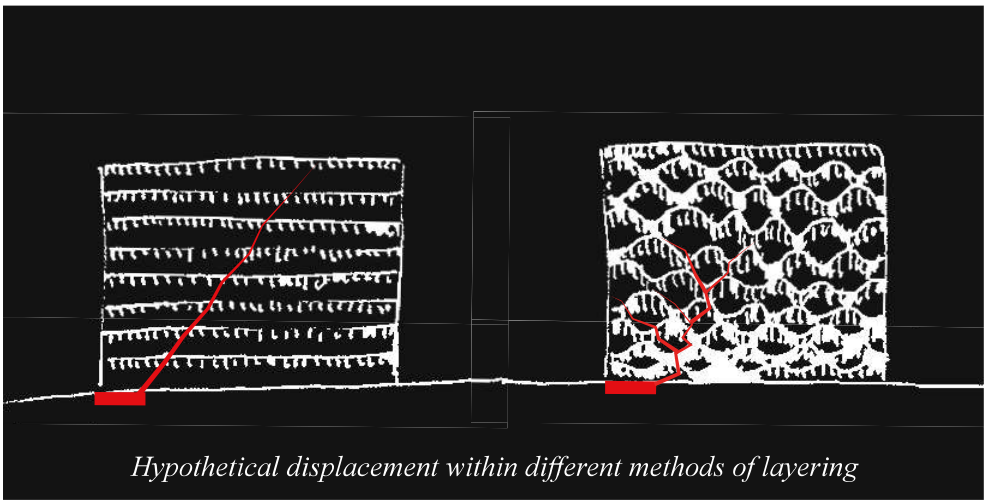
In-form formwork parts



Alternative ramming strategi

Layering of Earth weave

Test
Weaving Earth
Gothenburg
Earthlab
24/4



Hypothetical displacement within different methods of layering

Test

Trial by Water
Earthlab
30/4, 27/5 2020

A test based on some heavy spray of water during 4 x 15-20 seconds.

The obvious result being the most compressed parts cooped the spray for longer. But also the two layers of fiber withstood better.

Waves and broken waves in the compressed pattern, due to that the water needed escape somewhere.

Where the materials met, in this case where the weak material (earth), met the strong material (wood), the force and decaying water motions went through the weakest material first. The proximity of a strong material to a week material might also speed up the decay locally if the water is trapped. As for for water running over earth, the earth will give away in particle after particle till the water can escape, but adding a stronger material to the equation, the water could ”bounce back” or remain in the weaker material till it gives away and releases the water. As for this test, the water had gnawed more to the earth closest to the wooden board than any other part of the wall surface. A display of the importance of how these connections of materials are met to provide ways for the water to escape.

As for the current Zingira construction in Dunga with a strong material, the concrete foundation, the gradual increasement of cement towards the foundation will most likely level out the differences.

15 min spray of water.
The surface lost material till it reached the rougher gravel and small rocks, where the degradation of the surface stopped. The water then further gnawed on the edges of the sample, mainly the top and bottom, while not making it past the compressed levels of the earth during the time of the test. The weaving layers eventually appeared both in top and bottom of the sample.

Test

25/5 2020
Trial by Stress and Compression
Vasa

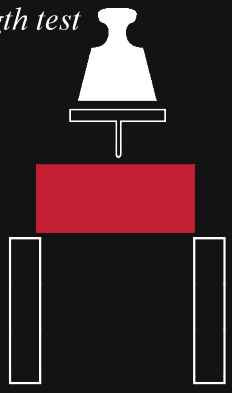
A test to see the flexural strength by applying a point load the material. A disclaimer, since this is a home made test it is not very valid in terms of comparison with previous test, but gives an indication of the different compositions within these batches. We did make two batches, one with slightly less water content (12%), the that we think performed worse then the second batch with 15% water content. The samples, in three compositions, three with 5% added concrete to the composition, two only Marram references, and three with added water hyacinth fiber.

Flexural strength test

Pure Marram	Water hyacinth	Cement
6,5 kg *	12,5 kg **	>3 kg *
5,25 kg *	11,75 kg *	10-11,25 kg **
	16,0 kg **	5,5kg *

**Batch 1, 12% water, **Batch 2, 15% water*

Flexural strength test



We also did a minor compression test for the fun of it, but it ended up too inconclusive. One test with cement, that raptured at a load of 21,25kg and one test with fiber. For the sample of the Hyacinth we ran out of weights, and had to use one Che Yu Liang, a weight that the sample couldn’t withstand.

As indications goes, the fiber performed quite well in comparison with the only marram samples and the cement mix samples. However, in this sample size, the cement reacts quickly and hardens already when its rammed. So the outcome may have been random, and would require either bigger test samples and maybe more water to the mix to provide clearer indications.

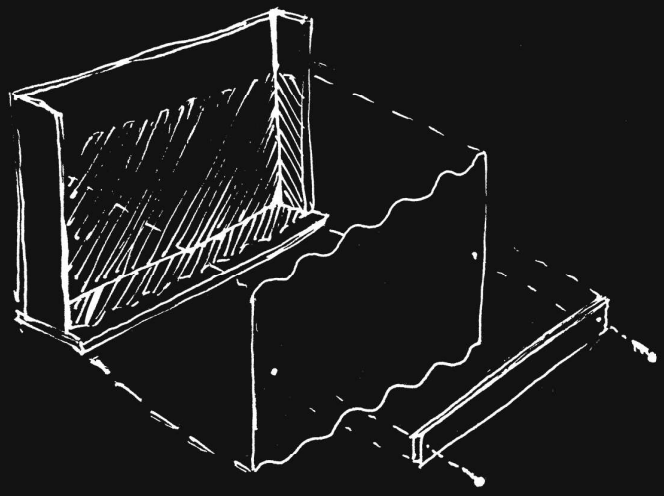
Gothenburg
Earthlab
Trial by water
30/4, 27/5

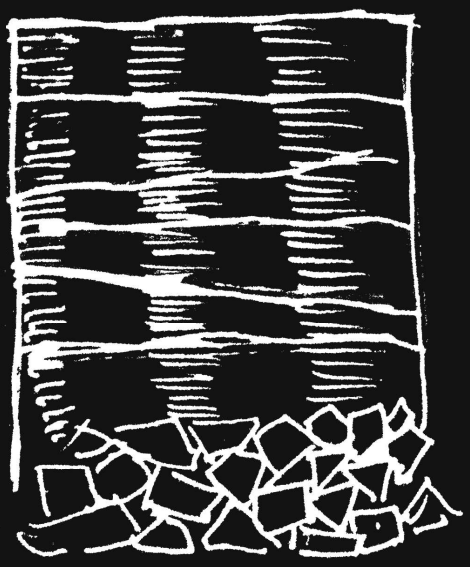
Corrugated Test

Gothenburg
Eartlab
22/5 2020

The Formwork for the prototype was made as a fixed one time only construction. The corrugated steel on one side, and a stiff plywood backdrop on the other side.

Material:
Sand and gravel from Västlänken/Hagakyrkan
Clay from Marieholmstunneln.
Fiber from water hyacinth



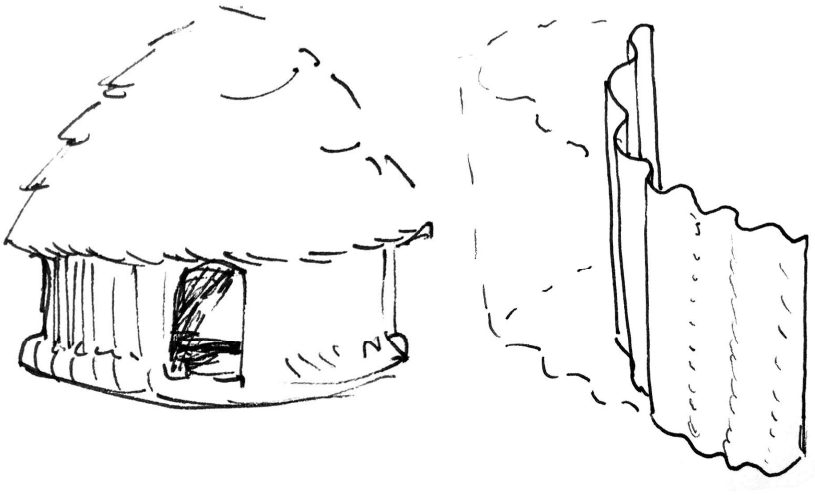


The sand from Västlänken contained medium sized rocks that were sorted out. These rocks would play the role of the foundation. One aspect of doing a foundation of rocks is that it becomes labour intensive and add costs in that sense. A way of bypass this would be to approach the foundation as a slightly upgraded and designed pile of rocks.

With that aspect in mind we simply added 1 part clay, 2 part sand to roughly 6-7 part rocks, and poured it out at the bottom of our formwork and then rammed it. The top layers we added 1 part clay, 4 parts sand/gravel, and a hand of fibers from the water hyacinth. Once again maybe a bit to high clay content, making the layers slightly more wet then desired.

What did this give us? It stressed some considerations for the foundation, Where pockets of air appeared in these layers (we might have had to high of a clay content as well), making this method not to have on layers above the foundation. It may as well stress the need to exaggerate and adding more material to the foundation to a “Kisumu bulb”. We didn’t add lime in these parts for the prototype, but we would suggest it, as well in the plastering covering the foundation. One aspect of the foundation is that it is to stop water from being sucked up from the ground by the material of the top layers of rammed earth, and lime as stabiliser here would make some difference. The wormwork of corrugated steel may need some temporary stiffening if it is to bulge not too much.

Corrugated Test
Gothenburg
Eartlab
22/5 2020



A conclusion from the previous water test, was that the edges of the sample became the weak spots. Thinking back to Kenya, it dawned on us that the original earth buildings there were round shaped huts, and thereby in it's purely architectural form lacked edges and thereby could better cope with rain. When considering the formwork, the fact that the corrugated metal sheet did flex and bulge, we first considered this a weakness. But it may actually be its biggest strength, if the formwork can perform round corners or if desired a round building.

Legacy/Conceptual database

Methodolagy of adapting in different context - *Kisumu, Kenya, etc.*
Stuctured workflow - *Testing process/schedule, Building sequence*
Potential and concept - *Practical practice and experience*

Reproducibility

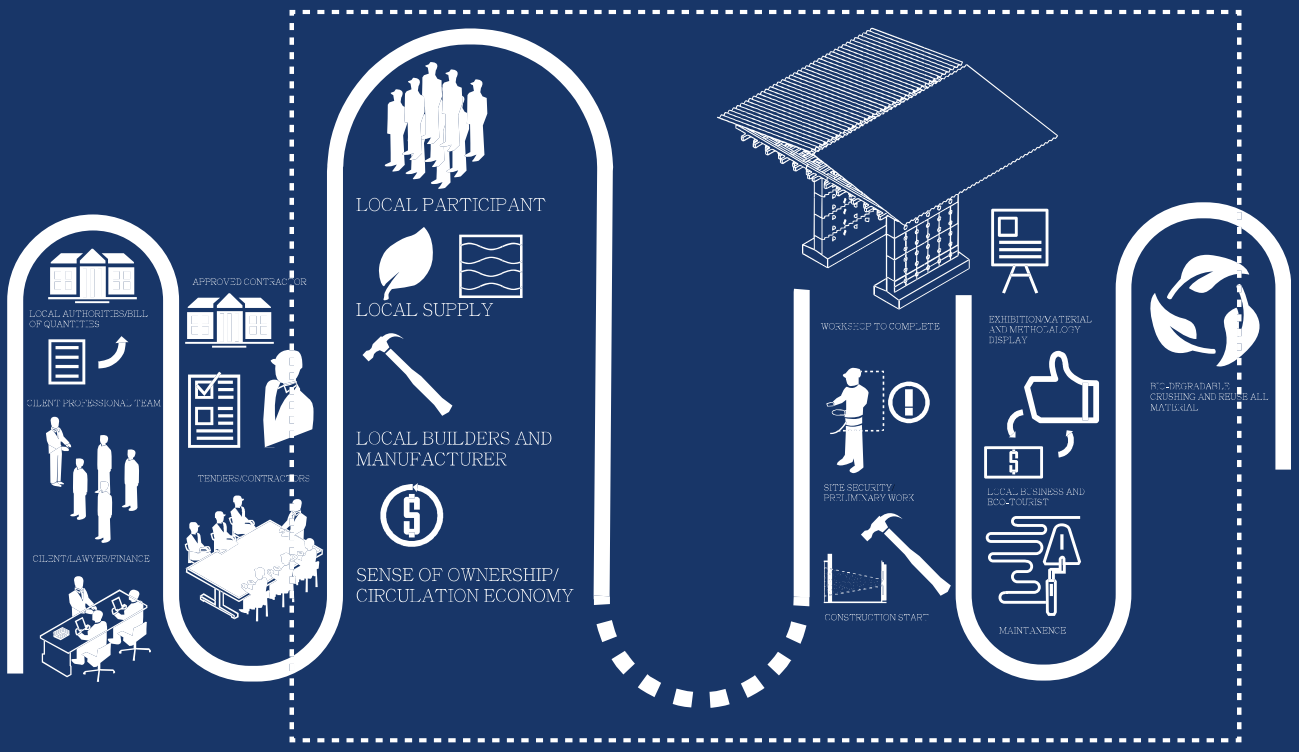
Adapting to Gothenburg
Frihamnen & Oceanbryggeriet
27/4 2020

One aspect in determining how successful the project can be is how replicable or adaptable it is to other sites and situations.

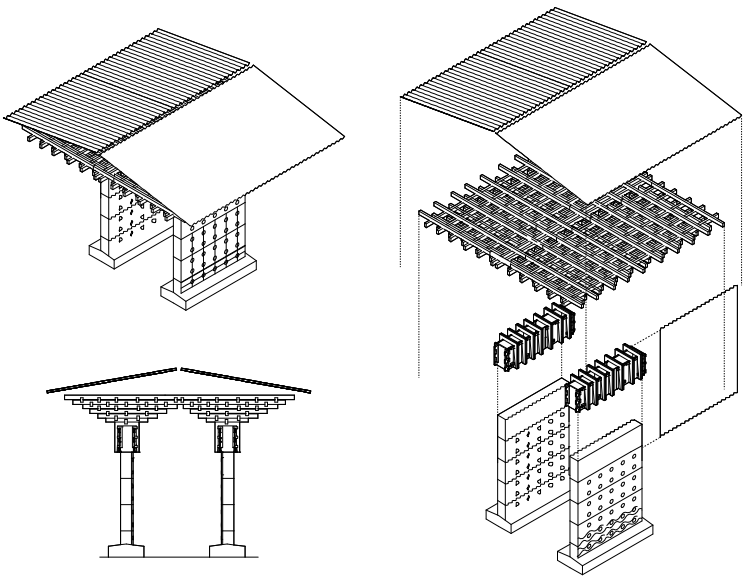
A deviation and what we had as a possible outcome of the project was to try out how well it could be translated and formulated in the sudden Swedish context that we found yourself in during the pandemic.

As a possible site, Frihamnen, Jubileumsparken, the informal space with ephemeral structures built by Gothenburgers inside Gothenburg. It is not the same context as in Kisumu, but we thought it could perform similarly. By allowing a co-created space to become an arena or a workshop for what sustainable materials or techniques are available locally. Either becoming a learning ground by participation or by its location.

As for material and approach to the composition, a way of of translating it is not necessarily using the most similar material available, but using the materials that fits the same idea of being a low-value material upvalued in i a construction. As for Gothenburg, this meant clay from the various Infrastructure projects, with added fibers from leftover barley-residue from the local beer industrie (Oceanbryggeriet), the latter one, with inspiration by a previous master thesis project “Tales of the revived” (Eliasson, Moberg, 2019), was conveniently available material at this time of year. As an adaptation this would both mimic the method of low-value materials as well as material composition reinforcing clay with fibers.



Gothenburg
Oceanbryggeriet
Barley residue
fiber
27/4



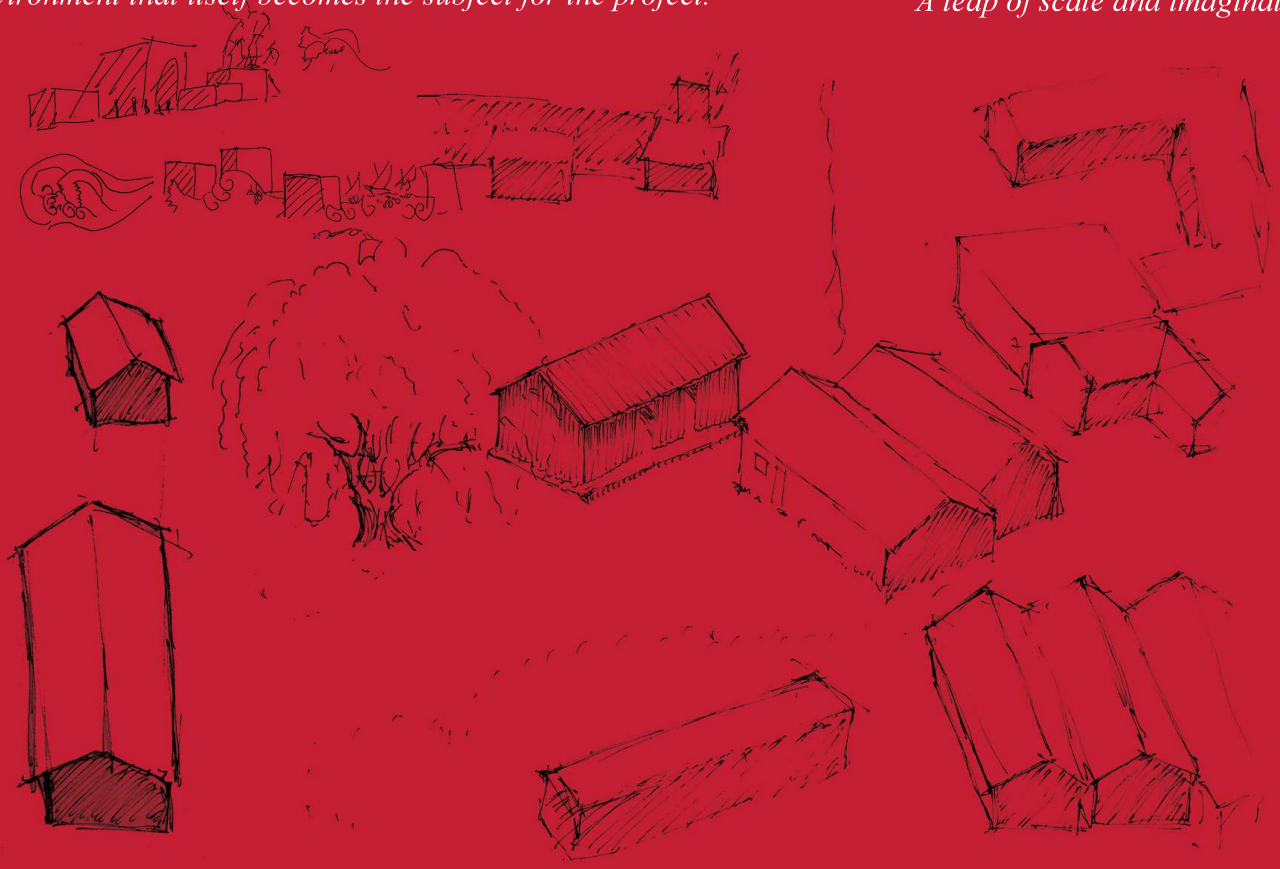
Gothenburg Cocreation concept
Frihamnen Jubeleumsparken

Intended prototype, but time and circumstances left in on the drawing board, Composed out of a ”Mexican larry”, bulb base, reusage of metallsheet for roof and bottles for windows.

Concept

By using a toolbox that utilizes a concept of co-creation between different disciplines, test of materials, raising awareness of materials and traditional techniques to be combined within the discipline of learning, all within a school environment that itself becomes the subject for the project.

A leap of scale and imagination.



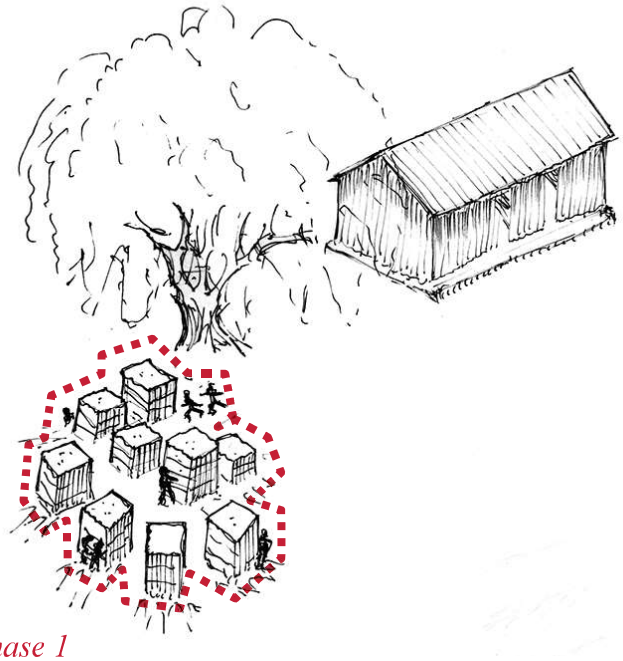
Obunga, Juliana School

A return to Kisumu and a hand over to the next year.

We left Kisumu in the middle of the consequences of the Covid-19. As a lockdown measure, all the schools were shut down two days prior to our departure. This didn't stop the kids in Obunga from returning to the playgrounds of the Future Hope Primary School, despite the absence of teachers.

During events such as a pandemic lockdown it becomes clear how out of touch these actions can be when considering the society in informal settlements. These actions doesn't recognise how people are to provide food for themselves, nor necessary daily living and not the children who loses their daily routine and security of going to the schools. The children will most likely not have the same security at home, when being left at home alone due to the consequense of parents still must be able to continue to provide their daily living. Consequently, the children here returned to the secure place they knew of, the playground in their school.

During our first introductory week in Kisumu we did a visit to the Juliana School in Obunga. In 2017, a Reality Studio project, Playocracy (Lundström, Mohammadi, Mure & Siddu, 2017), made a playground with the children of this school. But since, due to "being too popular" it had been disassembled, it can be questioned if this was the real reason for the dismantling, but the result became all the same. The children once again lacked a playground.



Phase 1

Phase 1 Trial of material, the playground

Our test in Gothenburg gives an indication of the material property, but it would be reasonable to try it out in bigger prototypes before constructing a building with it. As a suggestion, these prototypes could come about in the form of a playground. Those who have visited the Berlin Holocaust memorial by Eisenmann, will recognise that simple volumes, despite the meaning, can evoke the urge to run and play. With that in mind a playground consisting out of simple volumes, prototypes testing the material, can be enough of a landscape to have fun in. Since the children of the Juliana School once again have a need for a playground, this would therefore be a suggested site.

Phase 2 - Upgrading a classroom

As a way to collect the knowledge, to make each stakeholder connect and to let schoolchildren know about each step in the process, a building process is established in coordination with the school where the stakeholder for each material are invited together with the Jua Kali involved in construction.

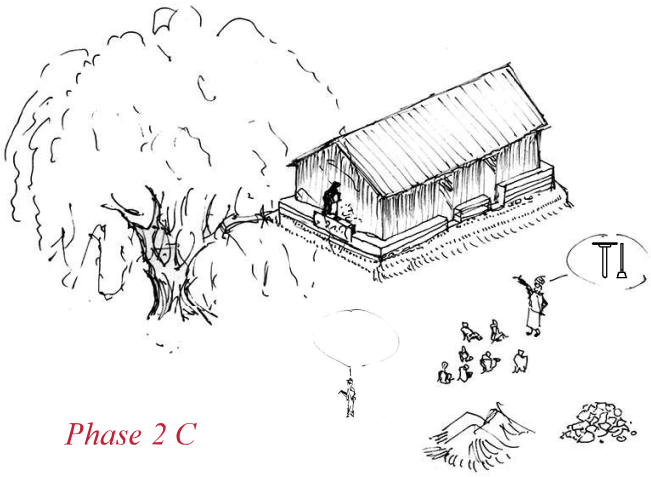
A foundation with an exaggerated bulb is made out of rocks sourced from the closest area. Bricks and concrete blocks are avoided. An earth composition is made and rammed against the current classroom where the metal sheeting act as the inside formwork. A way of upgrading while still being able to hold classes during the process.

Phase 2 A

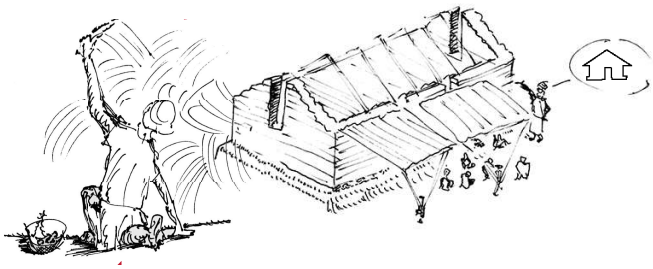
Phase 2 B

A workshop will be established where each craftsman, stakeholder and the schoolchildren can try and learn from various steps from each trade. This is then incorporated with a building process of upgrading the metal sheet classroom to a rammed earth building.

The process is shown by Jua Kali, while also explaining the connection and methods used within the existing traditional buildings, the aspect of what materials to use, and the value and relevance of maintaining and preserving methods and knowledge bound to the area and the existing building stock.



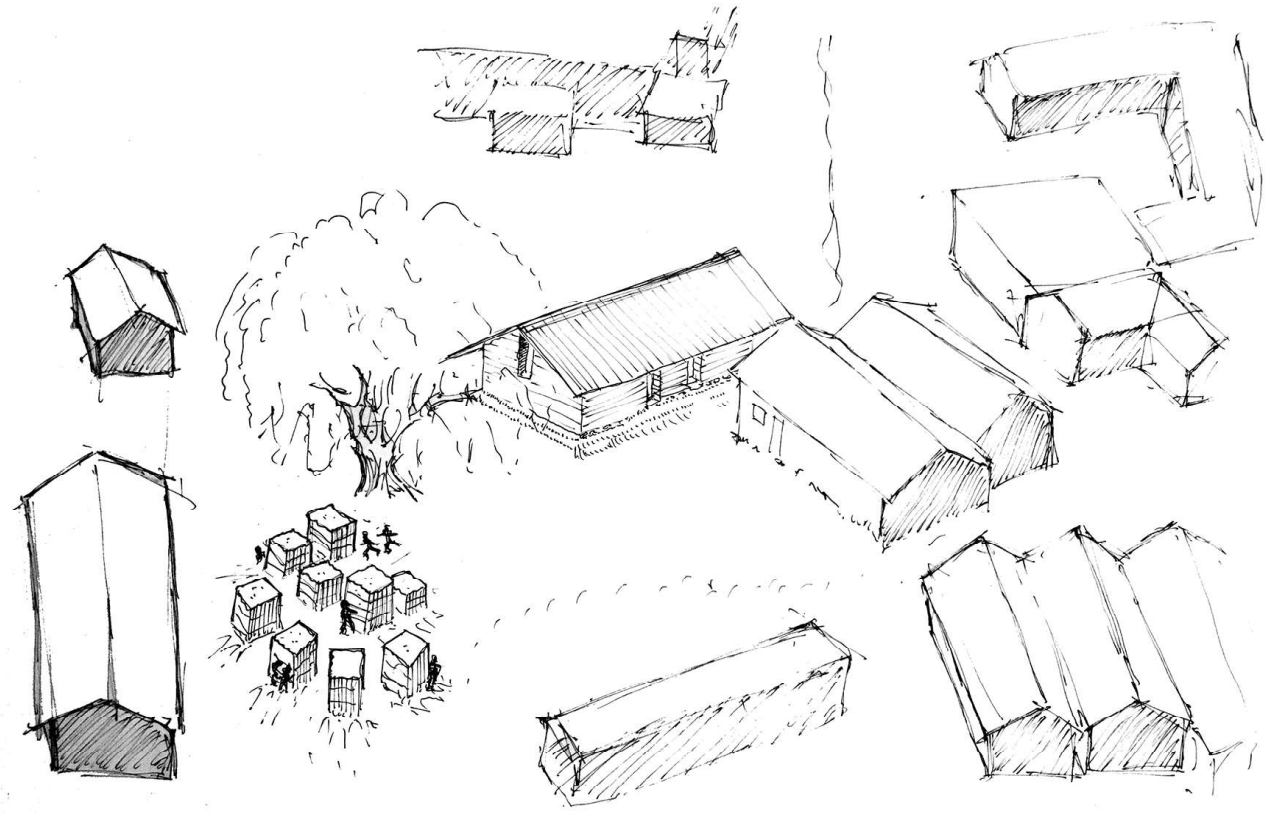
Phase 2 C



Phase 2 D

Due to the heavy nature of ramming earth, the plastering process by making patterns from Aloe Vera and corn cobs can be an introduction to involve the children in the process. This being traditionally the women's job, can be a part of engaging the mindset about women in construction. By connecting history with present by also involving women Jua Kali in the construction.

During the last phase a temporary outdoor classroom is made out of sheeting during the removal of the interior metal sheets. The roof is refitted and excess sheet material can be used as an inner ceiling, together with the thick earth walls this will provide an improved indoor climate and comfort in the classroom.



Phase 1 & 2 Final

Since our time in Kisumu was cut short, the amount of information we managed to gather is quite slim. However using a process of trial and workshop as this suggestion, a potential project would be adaptable to involve other schools, stakeholders and information relevant to the Kenyan building tradition and people in Kisumu.

Reflections

Approach and method.
As it turned out, we got focused primarily on a continuation dilemma. All these previous Reality Studio projects, ruched in to specific sites, use what means you seem fit, then utilize them the best you can and then reflect upon them. But to us it seemed the reflection part got lost on the receiver, either as in cost, to be reproducible or feedback to develop the concept. What we ended up doing, not knowing it in the speed of our journey, was that we picked up on developing previous ideas to make them reproducible and in the long term more achievable to more people before we got a project site to apply it on. By the time we left, we had the site for the Dunga construction to do prototypes, and a stakeholder in the jua kali to follow the journey in developing the material and technique. When we left, we did it still searching for a way to implement the project to the child perspective and develop the women business opportunities.

The hunt for a business opportunity
The source for the hyacinth was also our possible business source for women, as it turned out the harvesting took place further away from Kisumu then expected. Although equally beneficial it would be for this community as any other community residing along the Kisumu Homa bay, the constraints of time within a Reality Studio project would make it difficult to engage directly with this community, a project that would require several hours of daily travel. However, one possibility would be to formulate a future project that engage in a networking between the various groups and communities of women that involve themselves with the water hyacinth craft along the shores of the bay. Alternatively, would be to look back to the reason for the hyacinth not being harvested closer to Kisumu, the pollution produced by Kisumu itself. This pollution is subsequently absorbed by the hyacinth, however, if it turns out that being encapsulated within an earth wall is enough enclosure to make the polluted hyacinths harmless, then there may be a source of harvest and income for the communities closer to Kisumu. It would thereby also become a potential business opportunity for the communities of women earning their living in Dunga Beach.

The problem of the Toolbox
Although all the intents of getting around the pandemic with a distance solution, it is relevant to reflect if this gives the intended effect. Looking back at the previous project Ram up Obunga and the ongoing Dunga construction, it is noticeable that the participation and experience of that project is more valued than the actual reflection and suggested change made up in that Reality Studio student project summary. So a problem can be seen here, since for the Kisumu part of the project will be just that, an analysis and a try to provide a future toolbox. The question is how relevant this becomes for the relevant persons, such as Steve and other Jua Kali. The problem can be just the issue of feedback and communicating back. But not necessarily, because the confidence of trying out different techniques requires some safety, either in the confidence by experience of doing itself, or financial security. To test out a new solution is thereby not a certainty if the first is lacking, secondly if the condition of finance and being paid is dependent of a project is being made properly, then what space is there for trial and possible fail within the project? But maybe it is the other way around, a possible toolbox within future Reality studio projects. Some tools for the long process of providing some necessary freedom of try and error every year. All within a school of learning and getting confidence by doing and participating, that most people, the Jua kali among them, are educating themselves within

Ramming motivation by days

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