UN-HABITAT
FOR A BETTER URBAN FUTURE

Turkana Houses

SOUTH SUDAN MAJOR TRIBES.

- DINKA TRIBE HOUSING:

WALLS MADE OF CLAY.
DRY GRASS USED TO CREATE CONICAL THATCHING ROOFS.
THE DINKA SPEAK NILO-SAHARAN LANGUAGES.

- NUER TRIBE HOUSING:

ROUGH MUD WALLS
CONICAL GRASS WOVEN ROOFS.

DINKA CULTURE. (AND NUER).

- BELONG TO A GROUP OF CULTURES KNOWN AS THE NILOTIC PEOPLE.
- POLYGAMS.
- CATTLE BARNS. 12 M ACROSS. COMPACTED CLAY + STRAW AS FOUNDATIONS. ROOF STRUCTURE: BRANCHES OF ACCACIA OR OTHER HARD WOODS.

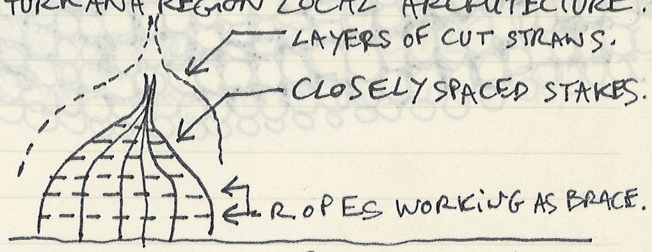
FOR ITS CONSTRUCTION: A WALL ABOUT 3M HIGH, BUILT OF CLOSELY SPACED STAKES. + 2 OR 3 SUBSTANTIAL ROPES WRAP AROUND THIS WALL AS COMPRESSION RINGS TO COUNTERACT THE FORCES FROM THE ROOF THAT IT IS DESIGN TO CARRY. THIS WALL IS USED AS A TYPE OF BRACE FOR NUMEROUS SLENDER POLES THAT RISE INTO THE SKY AND THAT ARE BOUND TOGETHER EVERY METER OR SO BY A RISING SEQUENCE OF COMPRESSION RINGS, EACH ONE SERVING, LIKE THE RUNGS OF A LADDER, AS A PLATFORM FOR BUILDERS. BY MAKING RINGS EVER SMALLERS, THE CONICAL-SHAPED DOME GRADUALLY COMES INTO SHAPE. ONCE THE STRUCTURE IS FINISHED, IT IS COVERED WITH LAYERS OF CUT STRAW.
PHOTOGRAPHER: GEORGE STEINMETZ/ASA.
BUILDING AND REPAIRS USUALLY TAKES PLACE IN THE DRY SEASON WHEN THERE IS PLENTY OF STRAW AND ENOUGH MILLET TO PROVIDE BEER FOR THOSE WHO ASSIST IN THE WORK.

NUER CULTURE. (AND DINKA).
DITO DINKA.

TOPOSA TRIBE

- HOUSES CALLED "TUKUL". CLOSE TO TURKANA REGION LOCAL ARCHITECTURE.

AZANDE.	KUKU.	MURLE
MUNDARI.	ACHOLI.	LATUKA
POJULU.	SHILLUK.	LOKOYA
MADI.	KACHIPO	LANGO.
LOPIT.	NUBA.	BOYA.



CATTLE BARN SYSTEM.

Turkana Houses

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Editors: Rosina Hawkins and Jia Cong Ang
Project managers: Yuka Terada and Laura Petrella
UN-Habitat Headquarters: Jia Cong Ang, Oana Baloi, Maryann Kithome, Olga Kouko, Jonathan Weaver, Baraka Mwau, Victor Mgendi, Andrew Ondoo
UN-Habitat Kakuma Field Office: Catherine Witt, David Kitenge, Naoya Kuboshima, Eric Muchunku, Bernard Heng Jia Chuin, Risper Talai, Wilson Karanja, Wilfred Lokai, Lucas Ewoi
Voluntary Architects' Network: Shigeru Ban, Yasunori Harano, Kunmi Park, Jun Fujisaku, Kyoko Ueno, Rika Tsuchihiro
Peace Winds Japan: Akemi Tanimoto, Moses Mukhwana, Philipp Nzuki, Chege Kamau, Geoffrey Wafula
UNHCR Jamjang: Mustafa Kur Lueth Kaman, Anita Corluka
UNHCR Kakuma: Sukru Cansizoglu, Mohamed Shoman, Anicet Adjahossou, Dennis Osewe
Lixil: Yu Yamakami
Makiga: Moses Kiroko, Peter Simiyu
Jomo Kenyatta University of Agriculture and Technology: Charles Kabubo
Statpack: Adarsh Shah, Godfrey Wanyama, Arthur Were, Julius Orwa, Musa Odera
Don Bosco Kakuma: Fr. Jose Padinjareparampil
Site work team: Gilbert Sandja Uledi, Sedar Kibumga Senga, Bruno Nabyo Amani, Omari Ndikumana, Catherine Arot, Nyaluak Choul, Nyaoum Patote, Isaac Nimbona, Ekai Nangolol, Moses Uwizeyimana, Idi Mahmoud
Design, and layout: Philippe Monteil

Cover and inside cover: 'Turkana woman'. Marker on recycled paper. Philippe Monteil. Jul. 2017

HS number: HS/050/20E
ISBN number: 978-92-1-132873-8

Turkana Houses

Housing Prototypes in Kalobeyei New Settlement
by Shigeru Ban and Philippe Monteil, with UN-Habitat support

United Nations Human Settlements Programme

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Foreword

In 1994, I saw photographs of poor shelters for Rwandan refugees and visited the headquarters of UNHCR in Geneva. There, I heard about their challenges in providing shelters as they did not want to encourage refugees to cut down all the local forests to make wooden frames. At the same time, when they provided metal tubes for the frames they were sold and replaced by wood.

Therefore, UNHCR was interested in my idea of using recycled paper tubes for shelter construction. As the budget was 50 USD for each shelter, I designed simple shelters using paper tubes and plastic sheeting.

Shelters made of PT and tarpaulin under construction. Byumba Refugee Camp, Rwanda. Feb.1999. © VAN

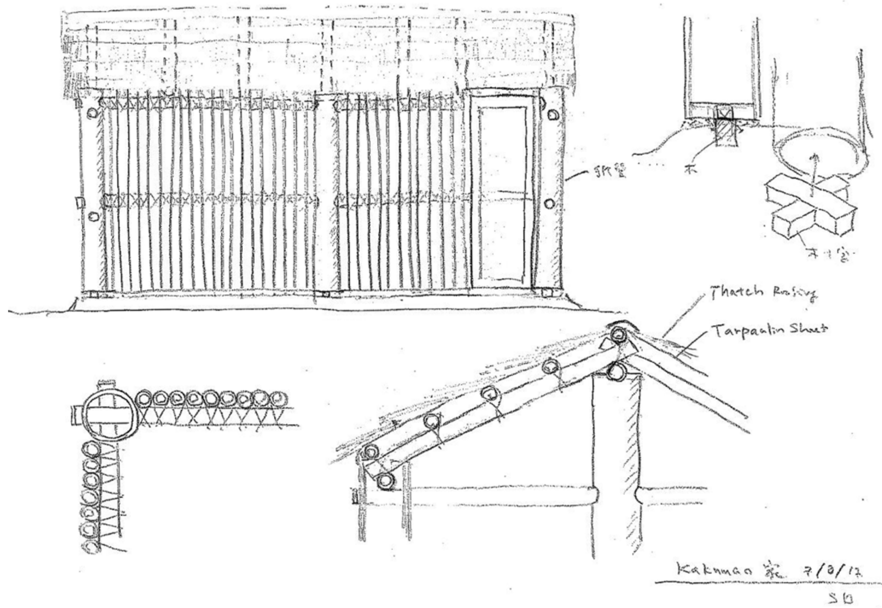
The project featured in this publication focuses on our experience developing houses for South Sudanese and other refugees living in Northern Kenya who were unable to go back to their original villages due to endless civil wars and conflicts. It was commissioned by UN-Habitat. Therefore, the meaning of 'refugee shelters' totally changed from my previous experience in Rwanda, as we sought to build 'refugee houses' that are not temporary but that could be used for many years.

When I visited Kalobeyei Town, I found houses of the nomadic tribe, the Turkana people. I learned about the locally available resources and building techniques of this nomadic tribe.

Turkana woman showing her building technique to Shigeru Ban. Kalobeyei Town. July 2017. © VAN

We also started investigating different building materials and vernacular housing techniques used amongst different tribes and refugee hosting areas. Our aim was to hire refugees and Turkana people to build their own houses using their traditional methods so they could maintain their houses by themselves.

Thus, I designed four prototypes with different materials and technologies, including structures made of paper tubes, which were available in Kenya.



Shigeru Ban's sketch for Kalobeyei Settlement. Structure and cladding made of paper tubes. August 2017

Type A. Paper tube structure covered with paper tubes.
Type B. Timber frame filled with burnt bricks. This structural system was developed for victims of the 2015 earthquake in Nepal.
Type C. House made of Compressed Earth Blocks.
Type D. Paper tube structure covered by branches of local trees used for nomadic houses.
In comparing the cost and durability of the 4 types, the timber frame filled with burnt bricks was chosen for the mass construction.

Philippe Monteil was our chief architect for La Seine Musicale, the music concert hall complex near Paris completed in 2017. After La Seine Musicale was completed, he moved to Nairobi with his children, and his wife who works for UNESCO. Therefore, he kindly accepted to manage this project, developed it further and enriched it with his leadership and ideas.

Shigeru Ban. July 2020

Foreword

I am delighted to present this publication on the work of UN-Habitat and Shigeru Ban Architects' Shelter Typology Design and Implementation project, as part of UN-Habitat's support towards the Kalobeyei Integrated Socio-Economic Development Program (KISEDP), in Turkana County, Kenya.

Over the last decades, the world has witnessed a rise in refugees and displacement caused by natural or human-made disasters and conflicts. Disproportionately large percentages of refugees, internally displaced persons (IDPs) and migrants are hosted by the most resource-scarce and poorest countries in the world. 40% of them live for prolonged periods in temporarily planned humanitarian and refugee camps, and 60% live in urban areas and cities facing numerous challenges which often include hostility and conflicts with host communities.

With these crises increasing in magnitude and frequency, and with the displacement of people becoming increasingly protracted, the responses by local governments and authorities, stakeholders and partners must be equally sustainable and long-term. Kenya, which has hosted refugees and asylum seekers since 1992 in the Kakuma Refugee Camp, established the Kalobeyei Settlement in 2015, aiming to pilot a new approach promoting the self-reliance of refugees and host populations by enhancing livelihood opportunities and service delivery. Subsequently, a 15-year comprehensive multi-sectoral and multi stakeholder initiative, the Kalobeyei Integrated Socio-Economic Development Programme (KISEDP) was launched, to create an enabling environment for inclusive housing, service delivery, investment and job creation, and build communities' resilience, skills and capabilities to enhance the overall local economy.

Aligned with the Advisory Development Plan for Kalobeyei Settlement developed by UN-Habitat, the collaboration with Shigeru Ban Architects since 2017 has seen the creation of unique Shelter Typology Designs using a highly participative process involving host and refugee communities. These prototypes have been constructed in a pilot neighborhood in Kalobeyei Settlement, not only demonstrating culturally sustainable housing solutions, but also serving to build a community.

I would like to express my gratitude to UN-Habitat and Shigeru Ban Architect colleagues for their commitment to the project, and for very thorough processes of design and experimenting to arrive at effective shelter solutions. A sustainability-oriented approach to refugee programming is necessary to ensure that the needs of both hosts and refugees are adequately met. I hope that this publication will support practitioners in this vital work, and can contribute to the body of examples that can inspire future programming.

Maimunah Mohd Sharif
Executive Director, UN-Habitat

Background

International Refugee Crisis, and Influx into Sub-Saharan Africa

The last half-century has seen a rise in global conflict, which has translated into an ever-growing refugee crisis. As of 2018, 70.8 million individuals have been forcibly displaced worldwide – with one displaced approximately every two seconds.[1] Sub-Saharan Africa now hosts more than 26% of the world's refugee population.[2] Most of these refugees originated from, and have sought asylum in, countries in the greater Horn of Africa region, which has continued to experience sustained armed conflict. Kenya, located in the East and Horn of Africa High Conflict Zone, has enjoyed, a relatively stable political and economic environment in recent decades, and has continued to receive a high number of refugees. As of January 2018, the total number of refugees and asylum seekers in Kenya was 486,460.[3]

Refugees in Kenya are hosted in major settlements and cities. As of May 2018, large refugee populations live in Dadaab Refugee Camps (208,616), Kakuma Camp (186,088), Nairobi (69,996) and Moyale (4,210).[4] In the establishment of these refugee camps, short-term emergency strategies took precedence over long-term development. For instance, traditional UNHCR T-Shelters enabled rapid emergency responses, but often failed to effectively respond to the long-term needs of refugees. Furthermore, refugee and host communities often live in hostile environments, where disputes over resource allocation and distribution can cause tension and conflict between communities, exacerbating challenging living conditions.

The Need to Expand Kakuma Camp, Kenya

Established in 1992, Kakuma Camp was initially developed to accommodate 30,000 to 40,000 Sudanese boys, who travelled across the desert into Kenya after they were forcibly returned to Sudan from Ethiopia. The camp expanded rapidly in the following decades, owing to a large influx of refugees coming from Sudan, Ethiopia, Eritrea and other conflict-affected areas in the region, resulting in the creation of Kakuma II, III (1990s – 2000s) and IV camps (2012). In about two and a half decades, the population of Kakuma camps reached 163,192 refugees from 19 countries, surpassing its initial capacity of 100,000.[5] Due to the continuous influx of refugees from war-torn South-Sudan and other parts of the Horn of Africa, along with the resettlement of refugees from Dadaab Camp, a clear need arose to expand Kakuma Camp.

Kalobeyei New Settlement was established in June 2015. The County Government of Turkana allocated 1,500 hectares of land to UNHCR and the Department of Refugee Affairs (DRA) in Kalobeyei ward, for the creation of a new refugee settlement. One of the conditions given by the county government and the citizens of Turkana County was that developments in the new site would share investments equally between the refugees and host communities. It was rooted in the opportunity for "growth stimulation", as part of Kenya Vision 2030, and as part of the Kalobeyei Integrated Socio-Economic Development Programme.[6] UN-Habitat was tasked with designing an Advisory Development Plan for the settlement, to accommodate 60,000 people – both refugees and host community members. A socio-economic mapping survey was conducted to inform the planning process. This was done with a focus on long term development – a paradigm shift away from the past humanitarian focus on sheltering refugees in short-term camps, towards long-term integrated planning.

UN-Habitat. Kalobeyei New Settlement

UN-Habitat is mandated by the UN General Assembly to promote the development of socially and environmentally sustainable human settlements. As outlined in the New Urban Agenda, governments and other actors are encouraged to invest

in, Sustainable Urban Development strategies to address the many challenges facing cities, such as informal settlements, growing inequality, environmental degradation, spatial segregation, economic exclusion and the growing challenge of migration. UN-Habitat recognises that existing forms of humanitarian aid do not provide long-term solutions to these problems, and is currently the only organisation creating a link between humanitarian action and staged development. UN-Habitat strives to implement a New Way Of Working (NWOW) in humanitarian contexts: working collaboratively towards collective outcomes across the UN system, based on the competitive advantage of all actors, and across multi-year timeframes. The planning process of Kalobeyei has been informed by the United Nations policy directives such as the Agenda 2030 for Sustainable Development, The New Urban Agenda, Universal Declaration of Human Rights, The Charter of the United Nations, The People's Process, Sendai Framework, and Sphere Handbook. UN-Habitat's planning process also adheres to existing legislations and regulations nationally and internationally. Multi-stakeholder coordination, participation and engagement in planning and development was designed to not only comply with the statutory planning process, but also to encourage long-term support and buy-in from government, development partners and the local community, to facilitate successful implementation of the plan.

So far, UN-Habitat's support to integrated planning and urban management has had several key achievements in Kalobeyei New Settlement:

1. Formed working partnerships with the County Government of Turkana, UNHCR, and implementation partners, in accordance with the spatial plan we developed;
2. Built capacity and urban management strategies within the Turkana County Government, increasing public awareness and ownership in the long term;
3. Facilitated a strong participatory process, incorporating the needs of host and refugee communities and developing planning strategies which empower all people, especially vulnerable groups;
4. Integrated urban planning of the settlement into the broader district, county and region, aligned with emerging local economic development strategies;
5. Implemented sustainable planning principles during the emergency phase, and forming the basis of the long-term urban design.

UN-Habitat's contribution to planning the Kalobeyei Integrated Settlement has also included a series of pilot projects such as the following: ICT and public space design, community centre construction, waste management strategy, renewable energy businesses, capital investment plan, horticultural farming training, road construction training, water dam construction, business establishing workshops, settlement development group mapping exercises, street light assembly training, transportation and mobility strategy, Lixil Corporation Green Toilet System sanitation project, donor missions with fundraising representatives and UN Directors.

Voluntary Architects' Network/UN-Habitat agreement

In April 2017, UN-Habitat contacted Shigeru Ban, a world-renowned architect known for his disaster relief projects, with the idea of developing shelters in Kalobeyei New Settlement. In July, an Agreement of Cooperation was signed between UN-Habitat, and the Voluntary Architects Network (VAN), Shigeru Ban's NGO, for the pilot programme: Shelter Typology Designs. As part of the agreement, UN-Habitat's Urban Planning and Design Branch was responsible for overall supervision and backstopping, including liaising with the local government. VAN and Shigeru Ban Architects provided in-kind contribution of Philippe Monteil, a senior architect advisor to develop shelter designs based on participatory feedback, including training shelter construction teams, developing innovative building techniques and details for shelter following UN-Habitat and international principles.

About Shigeru Ban's Disaster Relief Projects and the Establishment of VAN

Shigeru Ban first became involved in humanitarian work after he discovered that there were over two million refugees from the 1994 Rwandan Civil War living in terrible conditions. He presented his paper-tube shelter designs to the United Nations High Commissioner for Refugees (UNHCR), which hired him as a consultant.
After the Great Hanshin (Kobe Earthquake) in 1995, he built the Paper Log House for former Vietnamese refugees who did not have the opportunity to live in temporary houses provided by the Japanese Government. He also built the Takatori Paper Church with student volunteers. This was the trigger to establish the NGO, Voluntary Architects' Network (VAN), and to begin further disaster relief projects.
VAN went on to build temporary housing in Turkey in 1999, Western India in 2001, and Sri Lanka in 2004. A temporary school was built after the 2008 Sichuan earthquake, a concert hall in L'Aquila, Italy, and shelters after the Haiti earthquake in 2010. After the Great East Japan Earthquake in 2011, VAN set up 1,800 paper partition systems in more than 50 shelters, providing greater privacy for families. VAN also built temporary housing at Onagawa, Japan, improving many residents' quality of life in shelters and temporary housing. Following the devastation of the

New Zealand Canterbury earthquake in 2011, Ban built the Cardboard Cathedral as a symbol of reconstruction of the city of Christchurch.
In recognition of his dedication to the field, Ban received the Pritzker Architecture Prize in 2014, the most prestigious prize in modern architecture, which recognised his creativity and contribution to humanitarian aid.
The following chapters of the book will introduce Turkana County, through a journal by Philippe Monteil, which describes the collaboration between UN-Habitat and VAN to build shelters for refugees and host communities. The journal highlights the intertwined processes of exploration, design and construction, recounting the development of the project in chronological order up until the end of summer 2019. The goal was to develop sustainable and appropriate shelter options for people in Kalobeyei Integrated Settlement, and to give residents a sense of dignity and a home for long periods of displacement. It is hoped that this publication will contribute to shelter development studies internationally.

Notes

1. UNHCR, Figures at a glance. http://www.unhcr.org/figures-at-a-glance.html

2. UNHCR, Africa. http://www.unhcr.org/africa.html

3.UNHCR, Kenya. http://www.unhcr.org/ke/figures-at-a-glance

4. UNHCR, Kenya Statistics Package May 2018. http://www.unhcr.org/ke/wp-content/uploads/sites/2/2018/06/Kenya-Statistics-Package-May-2018.pdf

5. UNHCR, Kakuma Refugee Camp. http://www.unhcr.org/ke/kakuma-refugee-camp

6. Global CRRF, KISEDP Strategic Overview. http://www.globalcrrf.org/wp-content/uploads/2019/01/KISEDP-STRATEGIC-OVERVIEW.pdf

Turkana Journal

Part 1. Observing, Drawing, Building, Revising...from 2017 to 2019

In April 2017, Shigeru Ban called me to discuss a potential collaboration with UN-Habitat, to design houses for refugees in northern Kenya. He asked me if I would oversee the construction of housing prototypes on behalf of 'Volunteer Architects Network' (VAN), his non-governmental organisation (NGO).
Since then, 14 pilot houses have been constructed testing seven housing types in Kalobeyei New Settlement, in Turkana County, Kenya. The lessons learned are to be implemented in future large scale housing developments for the settlement.
The purpose of the journal is to share VAN's design process, recounting the events of each mission.
This work was undertaken with the support of UN-Habitat.

Notes for the reader:
1.The mission entries retain their form in present tense to emphasise the immediate impact of construction on the design and its resulting evolution.
2. 'Window', used throughout the text, refers to shutters (without a glass window panel).
3. After each mission, some extracts from my sketchbooks attempt to illustrate the interaction between the construction process and the design. Please note that the drawings reproduced are not the original size; therefore, they are no longer to scale.

Philippe Monteil. Feb. 2020

Observing, Drawing...

Kalobeyei New Settlement Study

Mission M00. Apr. Jul. 2017

April 14th. I meet Yuka Terada, UN-Habitat Programme Management Officer, in Nairobi. She describes the current site conditions of Kalobeyei New Settlement, and UN-Habitat's initial design brief for the houses. VAN must deliver the following:
- One design for 20 houses that will be built in Kalobeyei New Settlement
- Each will be at least 18m², with a budget of 1,500 USD per house (about $83/m²).
- Structures should be semi-permanent and designed to enable possible future extensions, to facilitate long-term development in the settlement
- A space for cooking in each house
- Consideration of climate conditions in Turkana, with features such as ventilation, flood prevention, sun protection, good orientation, etc.
- The design should use locally-available construction materials and employ residents of both the refugee and host communities, to create livelihood opportunities in Turkana County.

Turkana Context and UN-Habitat's Response

Following our meeting, I begin to research the context and background of the project, reading documents such as *Kalobeyei Settlement Advisory Development Plan*[1] prepared by UN-Habitat *(the final draft will be published in 2018)*. My first impression is that UN agencies have carefully considered the local context of Turkana County. The UN has thoroughly examined landscape and climate conditions, political and social aspects, and economic resources in the county.

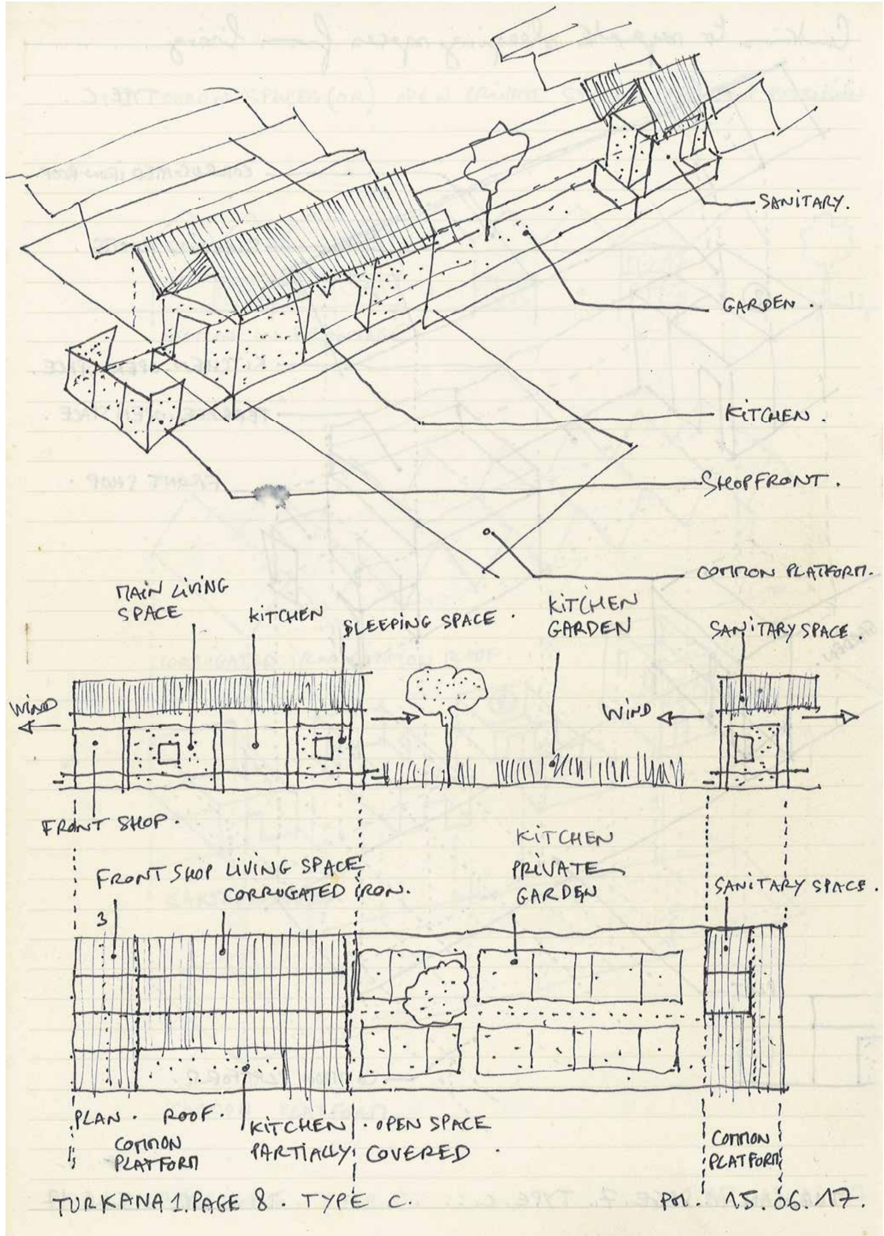


Fig 1. Initial sketch

From my research, I learn that Kalobeyei New Settlement is flat, dry and windy. Flash flooding occurs frequently during the short rainy season. In the design proposal, it will be essential to control the flow of water across the landscape to prevent flooding. In such a hot and harsh context it will also be vital to provide shade for residents. Most members of the host community are pastoralists, and land allocated to the settlement has reduced the space available for their livelihoods, causing significant tension. This social conflict may have been heightened by unequal international support, which has tended to favour refugees over host communities. This is something that UN-Habitat seeks to address in planning the settlement.

UN-Habitat's Advisory Development Plan for Kalobeyei New Settlement is multi-scale and comprehensive. It includes provisions for public infrastructure and services, transport networks and long-term housing. In the pilot project, houses will be built in blocks of ten. It is important to understand how these blocks of housing fit within the broader context of the settlement. The territory-level plan comprises a large agricultural corridor situated adjacent to the main riverbeds which divide the settlement into three neighbourhoods, each with 20,000 expected occupants. At the district level, public and commercial infrastructure and services are distributed along the minor riverbeds. This ensures residents have access to services within walking distance of their homes. At the street level, each block of 100 residents is organized around a community garden called an 'urban garden'. This will encourage greater self-sufficiency in each small community. Each house is designed for a maximum of five occupants, and is oriented so that shorter façades fitted with louvres face into the wind to improve ventilation.

Initial Sketches

June 15th. I begin translating some of the planning principles for housing from the Advisory Development Plan into preliminary design sketches. My initial drawings include features such as extended roofs for shade, space between the roof and underlying rooms to improve ventilation, raised platforms to protect houses from flash floods, capacity to add of kiosk infrastructure at the front of each house, an external sanitary unit, an open kitchen, and an adjacent vegetable garden (Fig. 1).

Researching Materials

Shigeru Ban is thinking of designing two pilot shelters, instead of just one. His first instinct is to use two tried and tested techniques from former VAN projects: Compressed Earth Blocks (CEB) and paper tubes. I contact a paper tube factory based in an industrial district in Nairobi and search for a contractor of CEBs in the same area. On the 17th of June I make my first visit to Makiga, a manufacturer of manual presses for making Interlocking Stabilised Soil Blocks (ISSB)[2]. The shape and dimensions of the blocks produced by the machine will determine the design and construction of the pilot houses. Two days later, on the 19th, I visit Statpack, the paper tube factory specialised in packaging. The production manager, Adarsh Shah, is skeptical about building houses with paper tubes.

Fig 2. One of the study photographs taken by Geoffrey Bawa during his visits to Bali, accompanied by Donald Friend and Wija Waworuntu, Batujimbar Bali, Bali, Indonesia, 1972–1975, ca. 1972–1975, gelatin silver print. M+ Hong Kong, Courtesy of Lunuganga Trust. © Lunuganga Trust
This temple probably inspired the design of Villa Batujimba.

Density Considerations in Kalobeyei Settlement

The design of the settlement in Kalobeyei is a response to the large influx of refugees to Turkana County, and development must match the density stipulated in the project brief. I begin to research housing density and modular designs. I think about how to include areas where extensions could be added by residents in future.

At first, my drawings include a shaded, open living space on top of the house, to optimise the use of available land. The idea came from *The Villa Batujimba*, by Geoffrey Bawa in Sri Lanka[3] (Fig. 2). Incorporating a protected and well-ventilated living room reflects the open living spaces of traditional Turkana dwellings. I draw

a timber structure supporting a roof which covers the interior and exterior spaces, and can be assembled in different configurations.

I then draw a larger-scale plan of an entire block, to ensure that the ideas and drawings resulting from my research align with the residential-scale plan and adhere to UN-Habitat requirements for each house: a shop front, two rooms, an open kitchen, a sanitary block, a vegetable garden etc. I decide to place two houses on each plot, each with patios. This is in keeping with UN-Habitat settlement density recommendations, and will improve the spatial relationship between each house and garden.

I finaly try to draw a future projection of the settlement, when it has developed into an urban centre of “extreme high density”, with many two-storey houses. Further along in the process, patios will be scrapped from the design.

Some sketches later, the idea of patios was discontinued, as Turkana traditions necessitate different structures. Pastoralists want to retain closeness with the land, which can be provided by building dwellings with large windows facing the landscape.

Following pages: extracts from sketchbook n°1. Living-space, residential scale, and density

. ONE TREE PER HOUSE . RANDOM PLACE TO ENSURE A GOOD VERNACULAR ISSUE .
. ISSB TECHNOLOGY FOR WALLS .
. WOOD TECHNOLOGY FOR SLABS AND ROOF STRUCTURE .
. SANITARY + KITCHEN BLOCK .
. LIVING SPACE AS AN OPEN SPACE . COVERED BY ROOF BUT OPEN TO OUTSIDE .
. SLEEPING SPACE INSIDE OR ABOVE HOUSE . ALWAYS COVERED BY ROOF .
. PV PANELS ONLY FOR LIGHT BULBS .
. RAINWATER RECUPERATORS . RAINWATER HARVESTING FOR AGRICULTURE .
. BATHROOM WASTE RE-USED FOR CHARCOAL . COOKING .

LOCAL SCALE BLOCK . 100 PEOPLE
↓
COMMUNITY SCALE BLOCK . 5000 PEOPLE .
↓
NEIGHBOURHOOD . 20 000 PEOPLE .
↓
SETTLEMENT . 60 000 PEOPLE .

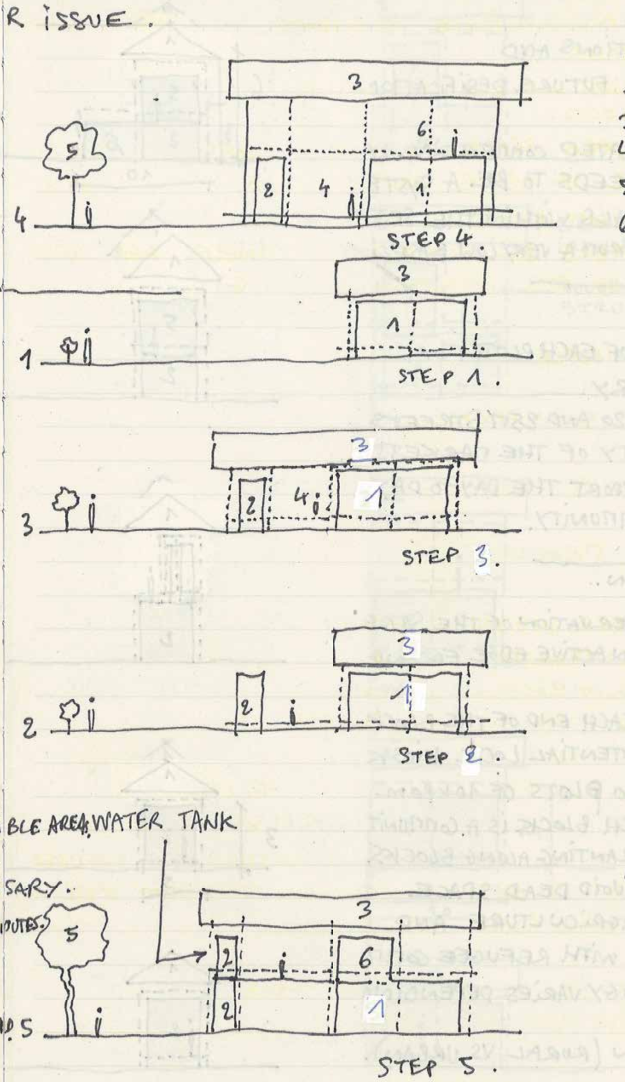
. PROMOTING INCLUSION, GENDER AND YOUTH SENSITIVE APPROACHES .
. KEYS ~~FOR~~ TO PROMOTE INTEGRATION BETWEEN HOSTS AND REFUGEES :
– SMALL SCALE MARKETS IN EACH NEIGHBOURHOOD .
– PROVIDING SPACE FOR INFORMAL LIVELIHOODS .
– ACTIVE STREET FRONTAGES .
– ENCOURAGING WELL-LIT STREETS AND PUBLIC SPACES .
– WATER COLLECTION POINTS 50 M MAX. FROM PRIVATE SPACES IN PUBLICALLY VISIBLE AREA.
– HOST COMMUNITY TO HAVE SHELTER IN AREAS TOGETHER WITH REFUGEES .
– TWO ROOMS PER SHELTER TO ALLOW FOR GENDER SEPARATION IF NECESSARY .
– LINKING THE EDUCATIONAL FACILITIES TO PUBLIC SPACES AND ACCESS ROUTES .

. PUBLIC SPACE NETWORK . MAJOR KEY TO LINK PEOPLE .
. WATER COLLECTION AND THE USE OF LATRINES WITH EASY ACCESS AND UNISOLATED .
. STREET NETWORK :
– NATIONAL ROAD NETWORK . A1 HIGHWAY .
– TERTIARY STREETS . 15 M ROAD RESERVE . ACCESS TO RESIDENCE .
– SECONDARY STREETS . 20 M ROAD RESERVE . CONNECTION BETWEEN RESIDENCE AREA AND SOCIAL FUNCTIONS .
– PRIMARY STREETS . 25 M ROAD RESERVE . LINKAGE BETWEEN NEIGHBOURHOODS . FOR COMMERCIAL, MIXED USE AND PUBLIC FACILITIES .
– ARTERIAL STREETS . 40 M ROAD RESERVE . SPACE CAN BE USE FOR INFORMAL MARKET STALL SPACES . PUBLIC BUS POSSIBLE .

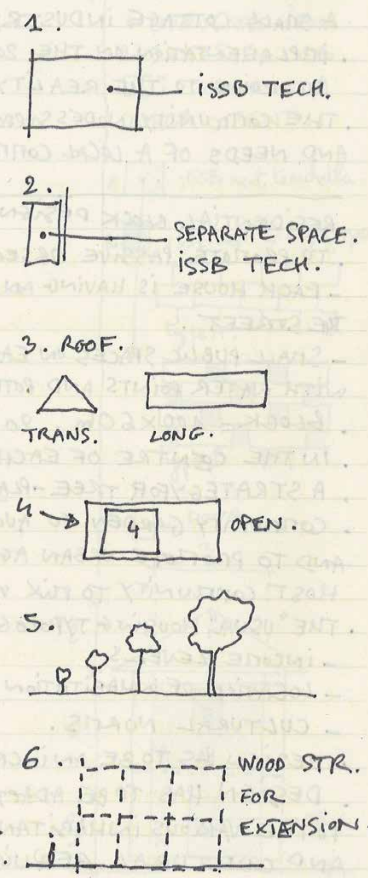
TURKANA 1 . PAGE 22 M. 01/07/17

TYPE C .

1. MAIN SPACE
2. SANITARY SPACE + KITCHEN
3. ROOF + WOOD STRUCTURE .
4. LIVING SPACE .
5. TREE HOUSE .
6. SPACE FOR EXTENSION .

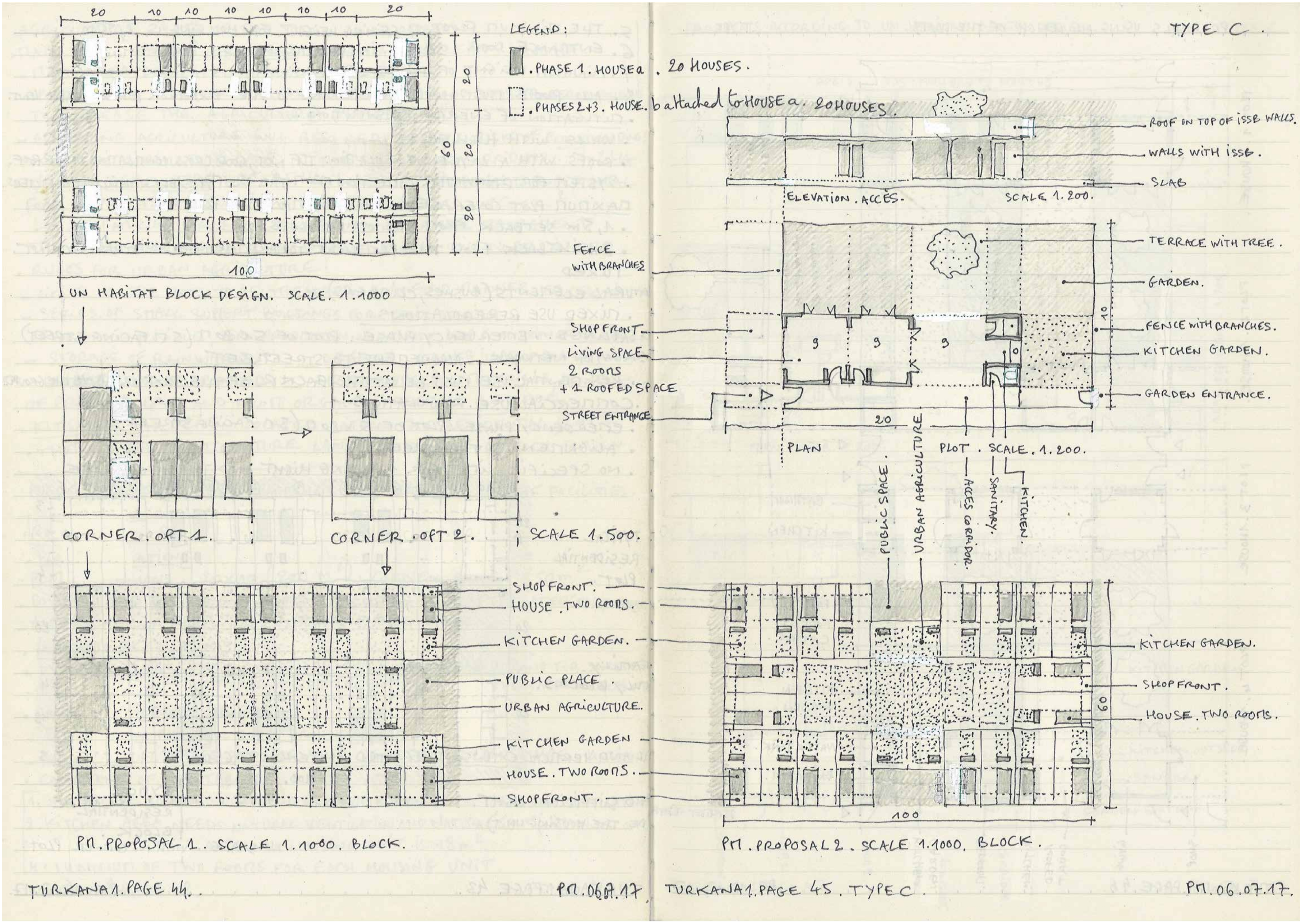


URBAN DESIGN .

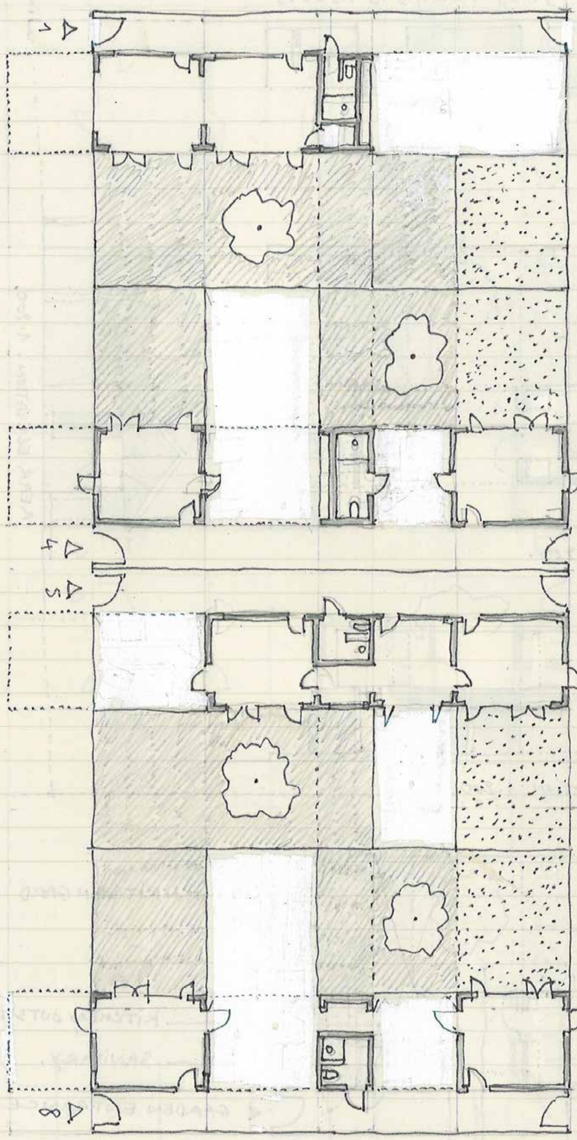


CONSTRUCTION FLEXIBILITY PROPOSAL

TURKANA 1 . PAGE 23 . TYPE C . M. 01.07.17 .


LEGEND:
. PHASE 1. HOUSE a . 20 HOUSES.
. PHASES 2+3. HOUSE. b attached to HOUSE a. 20 HOUSES.
UN HABITAT BLOCK DESIGN. SCALE. 1.1000
CORNER . OPT 1.
CORNER . OPT 2.
SCALE 1.500.
SHOPFRONT.
HOUSE . TWO ROOMS.
KITCHEN GARDEN.
PUBLIC PLACE
URBAN AGRICULTURE.
KITCHEN GARDEN
HOUSE . TWO ROOMS.
SHOPFRONT.
PM. PROPOSAL 1. SCALE 1.1000. BLOCK.
TURKANA 1. PAGE 44.
PM. 06.07.17
TYPE C.
ROOF ON TOP OF ISSB WALLS.
WALLS WITH ISSB.
SLAB
ELEVATION . ACCES.
SCALE 1.200.
FENCE WITH BRANCHES
TERRACE WITH TREE.
GARDEN.
SHOPFRONT
LIVING SPACE
2 ROOMS
+ 1 ROOFED SPACE
STREET ENTRANCE
FENCE WITH BRANCHES.
KITCHEN GARDEN.
GARDEN ENTRANCE.
PLAN
PLOT . SCALE. 1.200.
PUBLIC SPACE
URBAN AGRICULTURE
ACCES CORRIDOR
SANITARY
KITCHEN
KITCHEN GARDEN.
SHOPFRONT.
HOUSE. TWO ROOMS.
PM. PROPOSAL 2. SCALE 1.1000. BLOCK.
TURKANA 1. PAGE 45. TYPE C.
PM. 06.07.17.

BADGIR. TOUR DU VENT. WIND CATCHER. YAZD. IRAN. 20 HOUSES/BLOCK
TYPE C. 100 PEOPLE/BLOCK.



KITCHEN AT THE REAR OF THE HOUSE.

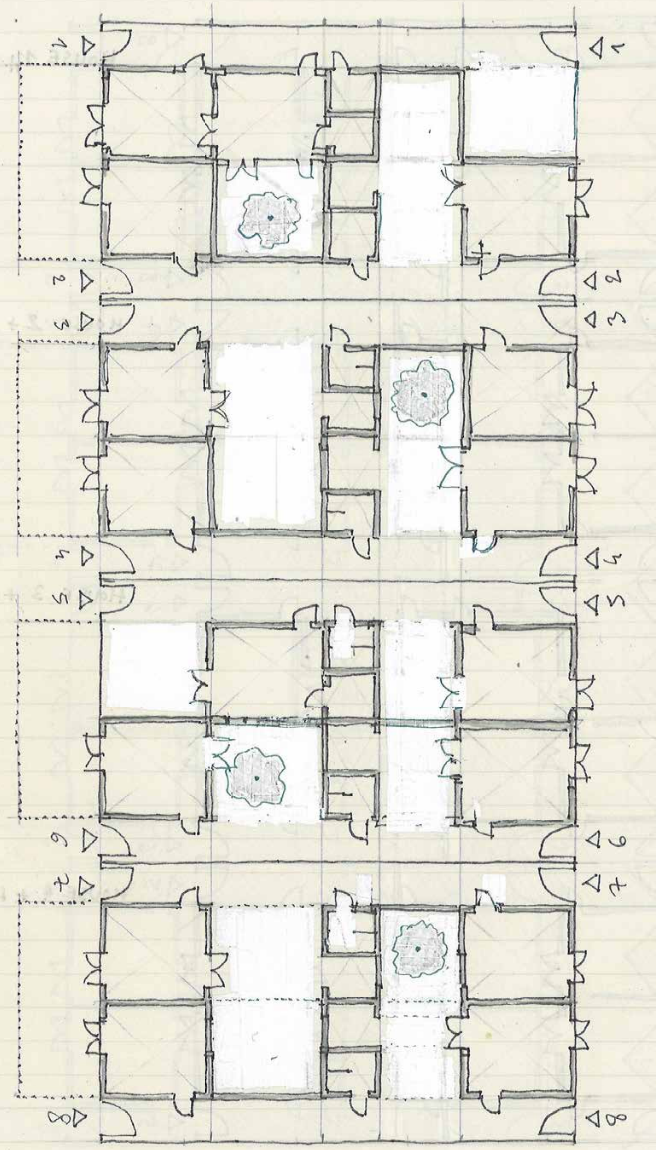
DAYTIME AND NIGHTTIME SEPARATED.

SHOP AND HOUSE SEPARATED.

SANITARY OUTSIDE.

TURKANA 1. PAGE 48. SANITARY AT CENTRE OF HOUSE. PM. 08.07.17

TYPE C. STREET + GARDEN ENTRANCES FOR ALL HOUSES. 40 HOUSES/BLOCK
200 PEOPLE/BLOCK.



TURKANA 1. PAGE 49. DIVISION OF PLOT FOR TWO HOUSES/PLOT. PM. 08.07.17.

First visit to Turkana

Mission M01. Mid-July 2017

July 14th. Shigeru and I are invited to visit the settlement site by Yuka Terada, to develop our understanding of the local context. We find that there are few building materials available in Kakuma Town: structural timber (2x2), mud bricks, Prosopis poles and corrugated iron. In Kalobeyei Town, we see some Turkana women building a hut. Shigeru observes their construction techniques: branches sewn together with lianas (Fig. 3). This marks a turning point in his ideas, and will strongly inform future design proposals. Our first impression of Kalobeyei Settlement is a remote landscape far from the main road. There are many transitional shelters (or 'T-Shelters') laid out to look like a military camp. People loiter on dirt roads, jobless. It is very hot and windy. It is hard to imagine that, sooner or later, the settlement will become like the bustling Kakuma Camp.

Shigeru signs the VAN/UN-Habitat agreement, which now requires three house designs for the pilot project, all using different building techniques and materials. This added diversity will increase our chances of success, and enable greater exploration of building materials and potential business opportunities for local people. As we fly back to Nairobi, Shigeru tells me, "The key thing will be to design and construct shelters which require little or no technical supervision, and to use materials that are locally available and eco-friendly. It is important that the houses can be easily maintained by their inhabitants."

Inspiration from the First Mission

July 27th. At our monthly meeting in Paris, Shigeru and I discuss the project. He says to me: "We should be interested not only in low cost construction, but also explore Turkana traditional techniques and materials to create employment opportunities.

1 *2* *3* *4*

Fig. 3. Turkana Hut under construction:

1. Homemade tool used to dig foundations
2. Positioning branches
3. Harvesting Prosopis branches
4. Sewing branches together with Sisal

The local Turkana people are building beautiful and well-ventilated houses, very quickly and with local materials. According to town planning guidelines and UN policies, we cannot build traditional houses in the refugee camp, but we must use local building techniques and materials which can be maintained and renovated by local communities.”

South Sudanese Vernacular Architecture

Following Shigeru’s advice, I begin researching traditional building techniques used in refugees’ various countries of origin - particularly South Sudan, as most refugees in Turkana have come from there, fleeing the civil war. I am amazed to learn about the varied communities in South Sudan, where 83% of people live in rural areas (Fig. 4). In a population of 11.2 million, there are more than 60 ethnic groups, though I can only find information about nine. These include Nuba and Shilluk peoples in the North; the major groups of Dinka and Nuer; Zande close to Uganda; Kapicho next to Ethiopia; Toposa from the Boma plateau; and Nyangatom, whose traditional lands stretch over parts of South Sudan and Ethiopia. Though there are tensions between these groups, their traditions and ways of living are very similar.

There is little available information on South Sudanese vernacular architecture, as most studies focus on conflict in the country in recent decades. However, I discover that 90% of South Sudanese live in *tukuls*, traditional round huts made of mud, luom grass, millet stalks, wooden poles, and a thatched conical roof[4]. Mud-brick cladding protects the people and their cattle from predators and flooding. The bricks are made of soil and grass mixed with water, and are cut into shape with a spade or similar tools and dried in the sun. The need for water, for building materials and pasture for livestock, means that the mostly nomadic communities tend to occupy land near water sources.

South Sudan Facts

Population estimate: 11.2 million in 2020 (Source: UN)
32 states and more than 60 ethnic groups
Ethnic groups are mainly Nilotics. 36% Dinka, 15% Nuer
The two main tribes are the Dinka (tribe of Salva Kiir, current president) and the Nuer (tribe of the Riek Machaar, rebel chief and former vide-president)
Religions: Christians 60.5%, Animists 32.9%, Muslims 6.2%, unaffiliated 0.4%
Illiteracy: more than 70%. Rural people: more than 80%
Life expectancy: 57
More than 1 in 10 children die before the age of 5
1 doctor per 10,000 people

South Sudan data sources:
http://www.fao.org/faostat/fr/#data
https://population.un.org/wpp/
https://en.wikipedia.org/wiki/South_Sudan
https://en.wikipedia.org/wiki/Religion_in_South_Sudan
https://www.cia.gov/library/publications/the-world-factbook/geos/od.html
http://uis.unesco.org/en/country/ss

Kalobeyei New Settlement

Fig 4. Right page. Principal ethnic and ethnolinguistic groups in Sudan and approximate home territories
Source: page 71/347 of publication 'The Sudan Handbook' from Rift Valley Institute

The Dinka Community of Pariang County

In his report on Pariang County, Mustafa Kur Lueth Kaman from UNHCR shares with us an excellent overview of Dinka construction materials and techniques[5].
In Dinka tukuls, he explains:
- The floor is made from the soil available on site, coated with water.
- The walls are made of 1.5m wooden poles, driven half a metre into the ground. These are positioned in a circle, and tied together with two or three thick ropes, which form a compression ring to support the roof. A mixture of soil, dry grass and water is left to ferment for a day, then applied to the poles.
- The roof is constructed from acacia branches, tied together with reeds in concentric rings to form a conical dome. The branches are then covered by a thick layer of woven grass, to ensure adequate waterproofing and as insulation against the heat.

Dinka villages usually consist of one large family, living in houses of varied sizes. Women and small animals, such as chickens, live in *huots*, the smallest houses. Men and cows live in *luaks*, large conical barns which serve as ancestral shrines. These larger structures are twelve metres in diameter, and require additional reinforcement with poles (Fig. 5).

Mustafa explains that when there is a lack of grass, it is applied in thin layers on huots, but Dinka will try to keep a thick layer on luaks for better insulation, because larger animals are considered a priority. The former enemies of the Dinka, the Nuer, have similar village structures and ways of living.

Climate-driven Architecture

Climate impacts the design of the houses across the entire region. Architecture appears to be defined not by political borders, but by proximity to water, whether near or far. In Kenya, the Turkana people cover their beautiful buildings made of branches with whatever they find around, which creates different looking tukuls both near and far from the lake (Fig. 6, 7, 8, 9, and 10). Returning to South Sudan, and looking closely at Nilotics and their region:
"The Dinka mainly live on traditional agriculture and pastoralism, relying on cattle husbandry as a cultural pride, not for commercial profit or for meat, but cultural demonstrations, rituals, marriages' dowries and milk feedings for all ages. (…) Cattle are confined to riversides, the Sudd[6] and grass areas during the dry season, but are taken to high grounds to avoid floods and water during the rainy season. (…) The Dinka's migrations are determined by the local climate, their agro-pastoral lifestyle responding to the periodic flooding and dryness of the area

Fig 5. Inside a Luak. An elevated bed for sleeping with cattle below, tied to pegs on the ground. The structure is made from 15-20 poles, depending on the size of the Luak. Photographs by Anita Corluka

Fig 6. Turkana huts covered with recycled material
Photographs by Winfried Bullinger. Marsabit County, Kenya, 2015

Fig 7. Left page. A couple of huts
Fig 8. Right page. Hut under construction
Photographs by Winfried Bullinger. Marsabit County, Kenya, 2015

Fig 9. Left page. Tukul near the lake, covered with a thick layer of Palm leaves
Fig 10. Right page. Tukul away from the lake, covered with a thin layer of Acacia leaves
Photographs by Winfried Bullinger. Kalokol, Turkana County, Kenya, 2016

in which they live. They begin moving around May-June at the onset of the rainy season to their 'permanent settlements' of mud and thatch housing above flood level, where they plant their crops of millet and other grain products. These rainy season settlements usually contain other permanent structures such as cattle byres (luak) and granaries. During dry season (beginning December-January), everyone

Fig 11. Nyangatom Achebe. Photographs by Winfried Bullinger. Kibish, Ethiopia, 2016

except the aged, ill, and nursing mothers migrates to semi-permanent dwellings in the toic [grass land] for cattle grazing. The cultivation of sorghum, millet, and other crops begins in the highlands in the early rainy season and the harvest of crops begins when the rains are heavy in June–August. Cattle are driven to the toic in September and November when the rainfall drops off and allowed to graze on harvested stalks of the crops."[7]

Further examples of climate impact on construction[8]:
- At high altitude in the Lopit Hills there are heavy rains. The Lopit people build houses with tiny entrances and thatched roofs that touch the ground. A thick layer of grass creates a barrier from water and insulates the house from the cold.
- Close to the Turkana border, the Toposa people build achebes, granaries on stilts to protect the harvest from floods and animals. These big baskets provide the community with shade (Fig. 11).
- The Nyangatom community lives in the dry, semi-desert lands of South-West Ethiopia and Southern Sudan, close to the Toposa. For most of the year they are nomadic, travelling with their herds, looking for green pastures. Their tukuls, made of woven twigs rather than mud, are set-up in temporary camps that can be packed and moved quickly if needed. The giant nets in temporary camps remind me of Turkana structures.

Lessons Learned. South Sudanese Tukuls and Turkana Huts

Based on my observations in Kalobeyei Town and my research on South Sudanese housing, it is clear that though dwellings may be organised differently, all local communities are looking for grass and water for their most valuable assets: goats for the Turkana, and cows for South Sudanese people.
In South Sudan, the majority of communities live along the Nile River, moving with the seasons. During the rainy season, they live in permanent tukuls, well protected from rain and heat by thick mud walls and thatched roofs. They then move with their cows to the Sudd – a vast wetland in central South Sudan – living in semi-permanent grass tukuls during the dry season.
In Turkana, herders are facing drought. This forces them to move constantly, and for longer durations, looking for grazing pastures for their goats. Due to lack of water their shelters are simplified, made from whatever twigs and grasses they can find. When they leave the camp, they take only their goats and a small metal trunk with a few valuable items. The giant nets are left behind, and will slowly return to nature. Like the Nyangatom houses, they are literally biodegradable transient shelters.

Following pages: extract from sketchbook n°2. Notes on South Sudanese architecture

KALOBEYEIL SITE ANALYSIS.

.WATERSHED AND FLOOD RISK.

4 MAIN RIVER BEDS RUNNING THROUGH TO THE SITE. ECOLOGICAL CORRIDORS.
WATERSHEDS DRY, EXCEPT IN APRIL AND OCTOBER BECAUSE OF HEAVY RAIN STOMS WITH FLASH FLOODS EXACERBATED BY FLAT TOPOGRAPHY AND SHALLOW WATERWAYS.
RIVERS AND TRIBUTARIES TO BE CONSIDERED AS PART OF A RESILIENCE STRATEGY TO PREVENT AGAINST FLASH FLOODING.

.TOPOGRAPHY

TERTIARY VOLCANIC ROCK COMPRISING COLLUVIUM DERIVED FROM BASALTS, IGNIMBRITES AND TRACHYTES ON THE SURROUNDING HILLS.
POTENTIAL FOR PLANT GROWTH UNDER NATURAL RAINFED CONDITIONS IS LOW.
LOW INFILTRATION RATE WHICH ALSO CONTRIBUTES TO THE COMMON OCCURENCE OF FLASH FLOODING.

. VEGETATION AND WILDLIFE.

7% OF THE SITE : RIVERINE TREES AND GRASS THAT GROW ALONG RIVERS.
23% OF THE SITE : OPEN GRASSLANDS FOR PASTURE DURING THE WET SEASON
70% OF THE SITE : VERY LITTLE OR NO LAND COVER AT ALL.

. ACCESSIBILITY

CURRENT ACCES TO ORIGINAL UNHCR DVP: THROUGH A1, LOCATED 300M AWAY FROM THE SETTLEMENT. COUNTY ROAD ACCESS POINTS AND LAPSSET CORRIDOR POTENTIAL ACCESS POINTS ARE NOT CONFIRMED YET.
TRANSPORT (LAPSSET) CORRIDOR IS A SOCIO-ECONOMIC GROWTH POTENTIAL.

. TOPOGRAPHY

SITE RELATIVELY FLAT, GRADUALLY FALLING AWAY FROM THE SOUTH EDGE TOWARD OF THE SITE BOUNDING THE A1 HIGHWAY TOWARDS THE WEST.
LEVEL CANGE : 30 M ACROSS THE SITE. AVERAVE SLOPE FACTOR: 0,5%.
SITE LIABLE FOR DEVELOPMENT BUT ALSO TO FLOODING.

. SUN PATH AND WIND DIRECTION

. 400 KM NORTH OF EQUATOR, SUN HAS A TYPICALLY HIGH ANGLE.
70° IN THE JUNE SOLSTICE AND 63° IN THE DECEMBER SOLSTICE.
AVERAGE TEMPERATURES: 27°. TO TAKE INTO ACCOUNT FOR THE DESIGN.
ESSENTIAL TO PROVIDE SHADOW WITH TALL VEGETATION AND ROOFS.
WINDS COMES FROM THE EAST AND SOUTH EAST. SHELTERS TO BE ORIENTED TO TAKE ADVANTAGE OF THE WIND FLOW IN ORDER TO FACILITATE PASSIVE COOLING.

LAND SUITABILITY ANALYSIS

URBAN DESIGN ACCORDING TO SOIL QUALITY, DEPTH AND SCALE OF WATER WAYS, RISK OF FLOODING. ALONG A1: DVP. NORTH WEST PART: AGRICULTURAL POTENTIAL

TURKANA 2. PAGE 2. PM. 18.07.17

SOUTH SUDAN MAJOR TRIBES.

. DINKA TRIBE HOUSING:

WALLS MADE OF CLAY.
DRY GRASSES USED TO CREATE CONICAL THATCHING ROOFS.
THE DINKA SPEAK NILO-SAHARAN LANGUAGES.

. NUER TRIBE HOUSING:

ROUGH MUD WALLS
CONICAL GRASS WOVEN ROOFS.

DINKA CULTURE. (AND NUER).

. BELONG TO A GROUP OF CULTURES KNOWN AS THE NILOTIC PEOPLES.
. POLYGAMS.
. CATTLE BARNS. 12 M ACROSS. [COMPACTED CLAY + STRAW] AS FOUNDATIONS.
ROOF STRUCTURE : BRANCHES OF ACCACIA OR OTHER HARD WOODS.
FOR ITS CONSTRUCTION: A WALL ABOUT 3M HIGH, BUILT OF CLOSELY SPACED STAKES. + 2 OR 3 SUBSTANTIAL ROPES WRAP AROUND THIS WALL AS COMPRESSION RINGS TO COUNTERACT THE FORCES FROM THE ROOF THAT IT IS DESIGN TO CARRY. THIS WALL IS USED AS A TYPE OF BRACE FOR NUMEROUS SLENDER POLES THAT RISE INTO THE SKY AND THAT ARE BOUND TOGETHER EVERY METER OR SO BY A RISING SEQUENCE OF COMPRESSION RINGS, EACH ONE SERVING, LIKE THE RUNGS OF A LADDER, AS A PLATFORM FOR BUILDERS. BY MAKING RINGS EVER SMALLERS, THE CONICAL-SHAPED DOME GRADUALLY COMES INTO SHAPE. ONCE THE STRUCTURE IS FINISHED, IT IS COVERED WITH LAYERS OF CUT STRAW.
PHOTOGRAPHER: GEORGE STEINMETZ/ASA.
BUILDING AND REPAIRS USUALLY TAKES PLACE IN THE DRY SEASON WHEN THERE IS PLENTY OF STRAW AND ENOUGH MILLET TO PROVIDE BEER FOR THOSE WHO ASSIST IN THE WORK.

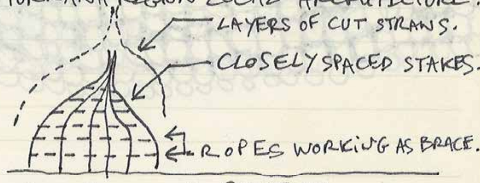
NUER CULTURE. (AND DINKA).

DITO DINKA.

TOPOSA TRIBE

. HOUSES CALLED "TUKEL". CLOSE TO TURKANA REGION LOCAL ARCHITECTURE.

. AZANDE.	. KUKU.	. MURLE
. MUNDARI.	. ACHOLI.	. LATUKA
. POJULU.	. S HILLUK	. LOKOYA
. MADI.	. KACHIPO	. LANGO.
. LOPIT.	. NUBA.	. BOYA.



CATTLE BARN SYSTEM.

TURKANA 2. PAGE 3. PM. 19.07.17

An Encounter with Turkana Architects

Mission M02. August 2017

July 31st. My first night in Kakuma. I strive to better understand Turkana building techniques, and begin interviewing South Sudanese refugees about their former houses in South Sudan. With David Kitenge, UN-Habitat consultant from the Kakuma office, I conduct surveys inside Kalobeyei Settlement. We meet women who describe their former dwellings as several houses with specific functions. Tereza Dario Hayang from Torit, a single mother with seven children, describes her former home: several tukuls with mud brick walls and corrugated iron roofs. One house is for the parents, one for the children, the kitchen is outside and the toilet is a detached corrugated iron structure. We only manage to interview four South Sudanese refugees in half a day, and realise we need more time. Together with Wilfred Lokai, a UN-Habitat consultant and Kalobeyei Town native, we decide to carry out further interviews in different neighbourhoods in the coming days.
The survey will be completed at the end of October, with a diverse sample of more than thirty refugees from various regions of origin interviewed.

Our aim is to show pictures from my research to South Sudanese refugees, to see if they recognise the housing styles, and to find out whether they are willing to share information about how these are constructed. Many people interviewed report using the same traditional construction methods: Nuer and Dinka both build luaks and huots; Toposa and Nganyatom both build achebes. Two key factors influence the architectural style of the region:

- Geographic location - in hot areas, huts are simply branches sewn together with some leaves as cladding. In cold places, roofing material is thicker, and structures are more complex in their construction.
- Social location - in villages, huts are made with any available materials found on the ground. In the cities, building materials are mainly purchased.

In addition, I ask participants to describe their living conditions in Kalobeyei New Settlement. Most complain that their tarpaulin[9] tents are unsafe because of the risk of snakes and scorpions, and also because thieves can easily cut through the material.

We finish the questionnaire by asking participants which type of house they would like to move into: one made of paper tubes, or one made from timber and bricks, CEBs, or another material. We also ask which construction style would be best for a future business. Responses highlight the need for protection: houses made of stone and CEBs are the number one choice. The Paper Tube House is interpreted literally as a 'paper house' - in our collective psyche, 'paper' is synonymous with fragility.

In terms of business opportunities, the Timber-Brick House and the CEB House are prefered, but the Paper Tube House is also considered an attractive option.

Fig 12. Anne's bedroom. Outside view

Anne's Houses

August 2nd. Wilfred brings me to the house, or rather houses, of Anne Ngasike, a single Turkana woman with three children who lives next to Kakuma Town. We enter through a corrugated iron gate, which opens to a large space with a tree,

Fig 13. Anne's bedroom. Inside view

a dry toilet shelter and a chicken coop. The space is protected by a thick fence of thorny branches. There is a second fence inside. We pass through a small door to discover a private courtyard with more houses. Each one serves its own function: kitchen, storage, bedroom, outdoor living space. The construction of all the houses appears traditional, except for the bedroom. Anne tells us that

Fig 14. Catherine's sleeping space

she applied mortar between the structural Prosopis poles to make them durable, reducing the need to recondition the mud walls of her house each year. Inside, there are fabric hanging along the walls, linoleum on the floor and some tarpaulin under the traditional roof to prevent dust. The house has a conical roof made of branches, artfully woven together and covered by a thick layer of reeds that come from Lake Turkana (Fig. 12 and 13). Branches and a thin layer of reeds cover the kitchen space. This is apparently sufficient to protect from the rain. Smoke from the kitchen is also able to pass through this permeable membrane. I am intrigued by the construction of the outdoor sleeping space, which has no roof and is designed to stand isolated. It is simply a layer of branches arranged in a semi-circular shape.

Catherine's Houses

August 3rd. I visit Catherine Arot's property, another Turkana architect, with Catherine Witt, a UN-Habitat consultant from the Kakuma office. It is a larger piece of land than Anne's, surrounded by a fence of thorny branches. Like Anne's, Catherine's household consists of a few buildings spread across the land. Each has a specific function: eating, sleeping, washing, and storage. Like the day before, I see a curious structure open to the sky. Catherine explains that because of the heat persisting during the night, most of the Turkana people prefer to sleep outside. This screen of branches provides privacy for sleeping, but also a view of the stars (Fig. 14).
As you will see in images throughout this chapter, the architecture of 'the sleeping space' varies from one family to another.

Catherine mentions she is also experimenting with new types of construction: a rectangular house with a wood frame filled with mud is currently under construction, as is a Prosopis structure covered by a layer of makutis cladding – dry palm leaf thatch – which has also been used as a layer above the tarpaulin sheet to waterproof the house. I am impressed by her excellent weaving skills. She will eventually become one of our partners, constructing the woven parts of our pilot houses.

The Paper Tube House

August 7th. Shigeru Ban sends me a sketch for a house made of woven paper tubes, a contemporary response from his experience with the Turkana constructions in Kalobeyei Town. The proposed design reflects his earlier words from the 27th of July: The paper tubes will come from Nairobi, but the assembly technique is from Turkana (see drawing page 9).

Outdoor Sleeping Space

August 8th. I start a series of drawings inspired by Anne and Catherine's houses, with consideration of UN-Habitat's planning principles (Fig. 15). A question remains unanswered:
How can we incorporate an outdoor resting space like in Anne and Catherine's courtyard into the design?

Three Initial Designs

Remembering Villa Batujimba, designed by Geoffrey Bawa, I imagine a covered outdoor room on the top of solid walls, a well-ventilated space that could be used for resting on hot days. The room will be high enough for sleeping outside. The next day, I complete the designs for three initial proposals:
- A solid ISSB block that supports a covered natural wood structure
- A natural wood structure with woven cladding, like a giant basket
- A timber frame filled with little stones found in the surroundings

The first proposal is inspired by Bawa's design, and uses locally-available materials including ISSB, Prosopis poles and thatch for the roof. During our earlier visit to Kalobeyei in mid-July, passing by Kalobeyei Settlement we observed South Sudanese refugees digging inside their T-Shelters. Our guide explained that lowering the floor level by digging down helps to keep the houses cooler. I decide to use the same technique, and lower the ground floor of the pilot houses. To avoid water entering during flash floods and the rainy season, I raise the door 15cm above the ground level. However, at this stage the design is still a draft with no detail.

The second proposal is inspired by Toposa achebes. The wood pole structure fixed on a 15cm stone foundation is covered by weaved Prosopis branches. As in the first proposal, I imagine a large, shaded and well-ventilated space on top of the house for resting. The cladding system acts as a railing for the outdoor space. It occurs to me that a refugee and a Turkana person will have different perspectives looking at the landscape from 2m above the ground, since Turkana houses are usually only one storey.

The third proposal involves a timber frame system similar to houses designed by Shigeru Ban in Nepal in 2015, except the filling is pebbles rather than burnt bricks. To keep the filling material within the frame and keep costs down, I suggest using plywood on the inside and Prosopis branches nailed to the outside.

After designing the outdoor resting house, I summarise the previous research

Fig 15. Sleeping area in Kalobeyei Town

through a series of elevations within the plot, returning to my initial idea of a one-storey house with an outdoor 'patio' living space. However, I bear in mind the unique land use of Turkana people, as they share communal land with others without territorial boundaries. Patios might be a good answer for density control, but perhaps not the appropriate answer for Turkana people who are used to looking at the horizon.

Timber Structure Assembly Details

August 11th. I open *Silent Spaces: The last of the Great Aisled Barns*, a beautiful book on mediaeval barns[10]. I copy the wood assembly details, trying to understand the complexity of these singular structures which use no nails or screws. After this exercise, I start to apply similar smart details to the wood deck house of the first proposal. The sketches show how we could assemble the wood structure, but also how we could interlock the ISSB. I imagine a wood ring beam with a groove at the bottom, which can form a negative/positive interlocking connection with ISSB blocks, like a "Lego" system.
Later on during construction of the Type C pilot, we will replace the wood ring beam with a reinforced concrete beam. The stability of the walls was compromised as timber procured from Kakuma was twisted.

Thatched Roof Assembly Details

August 23rd. Following Shigeru Ban's instructions, and looking closely at South Sudanese tukul roofs, I try to understand how we could assemble the tufts of reeds on the wood structure. I have the idea to cover the entire house, roof and cladding, using the same material. I am again influenced by the beautiful achebes made by Toposa people.
Later on, a lack of available reeds will lead us to change the roof material to corrugated iron. We will develop a specific construction detail to avoid the transmission of heat from the iron sheet into the house.

Testing Materials before Construction

In parallel to my exploration and interpretation of vernacular architecture, I ask Makiga to produce a few ISSB blocks using soil from Kalobeyei, in preparation for a test with Jomo Kenyatta University of Agriculture and Technology (JKUAT) which will enable us to better understand why the previous CEB pilots made in Kalobeyei Settlement did not meet construction standards.

Fig 16. CEB sample with a mix of 1/3 surface soil + 2/3 ground soil

Before my mission in August, UN Habitat brought 40kg of Kalobeyei soil to Nairobi - half from the ground surface and half from deeper underground - which we delivered to Makiga for block testing. In mid-August, I pick-up the samples in their workshop. Four pieces have been made:
- 1 block with surface soil
- 2 blocks with ground soil (1m deep soil)
- 1 block with a mix of both (1/3 surface soil + 2/3 ground soil) (Fig. 16)

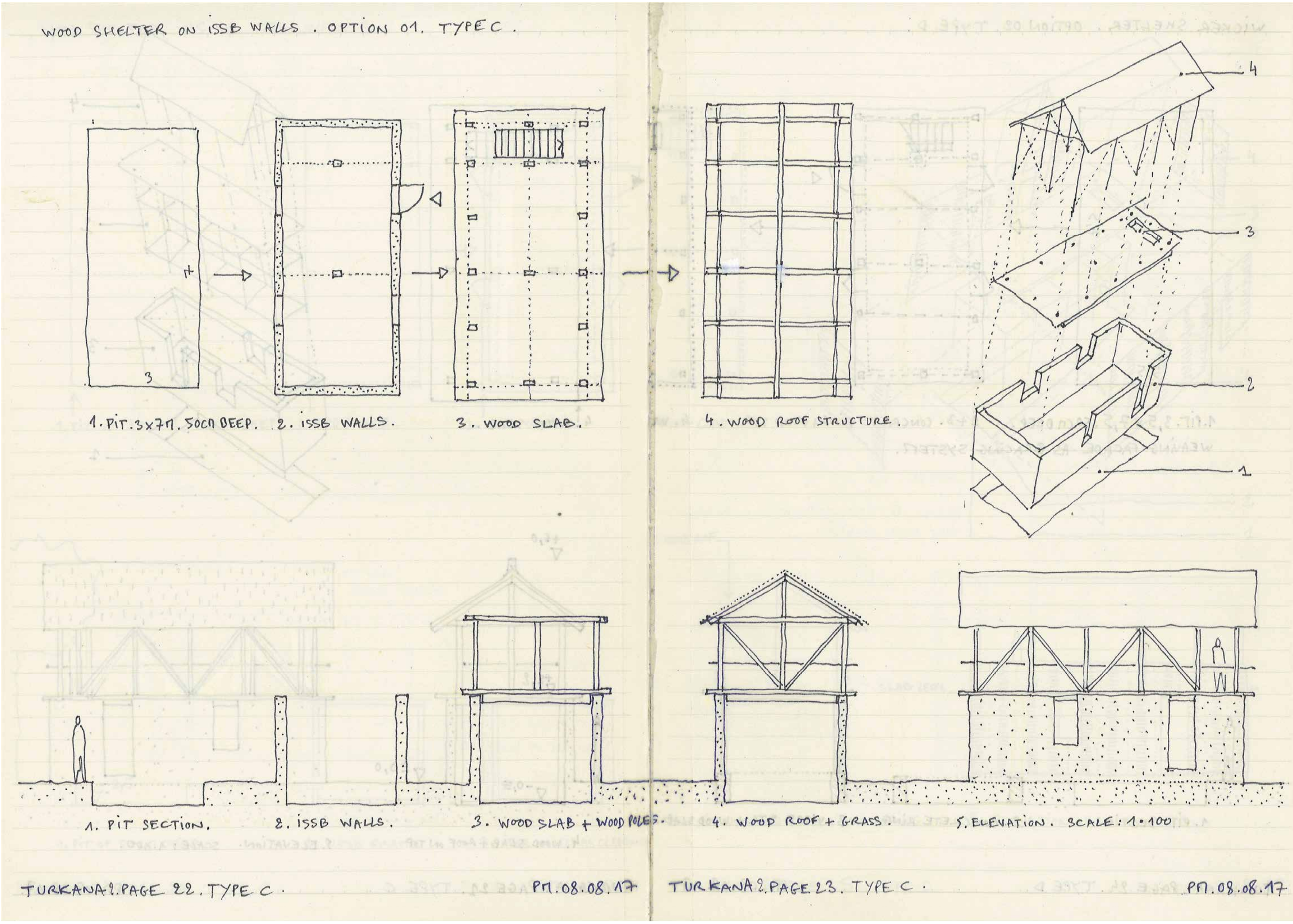
The soil underwent a sifting process to separate useable and unusable material. Almost half of the soil was unusable, so from 40kg of soil only four 7kg bricks

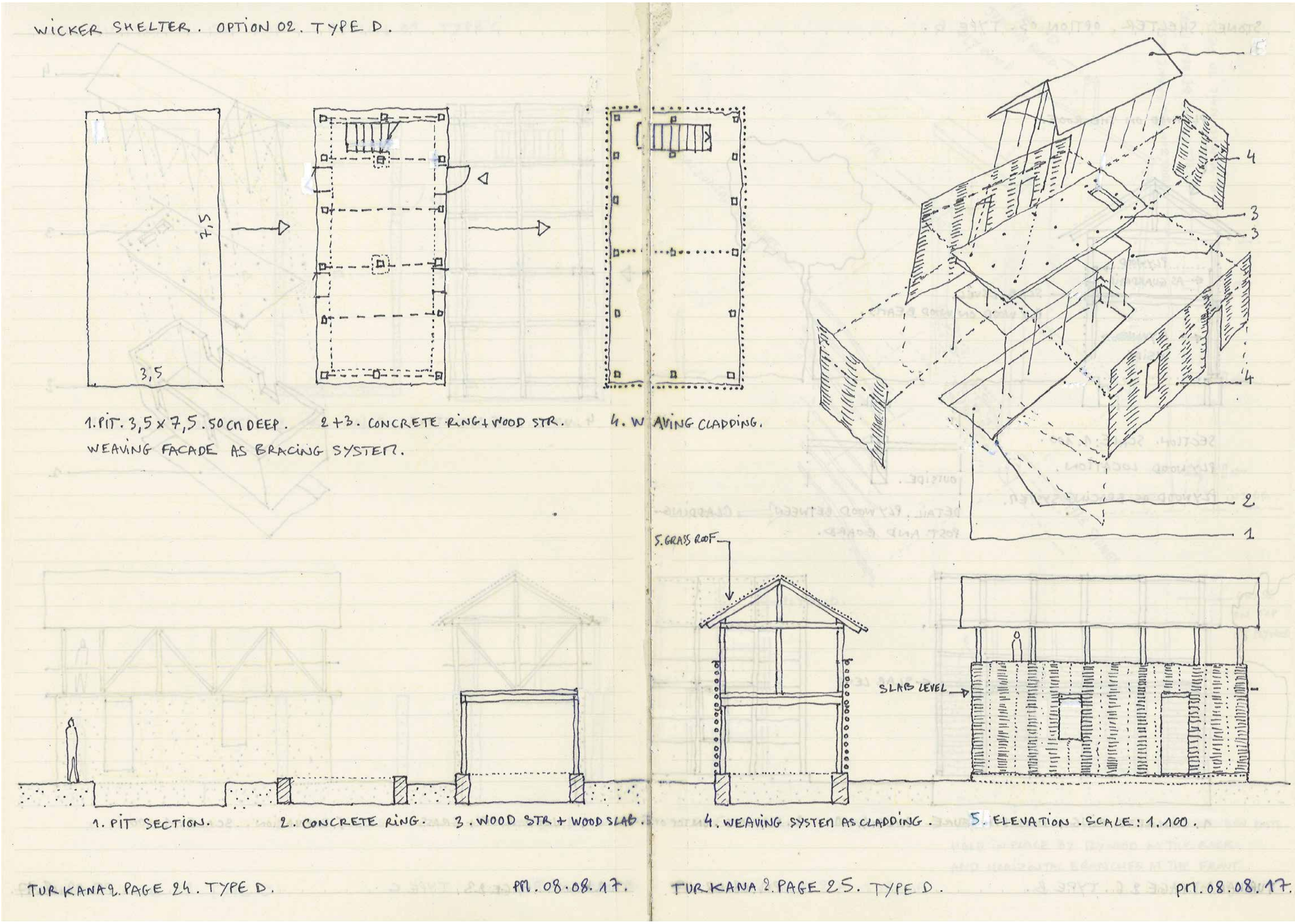
were produced. A shrink test reveals that sifted ground soil requires more cement, as it shrinks by almost 3cm. At the end of August, I take the samples to JKUAT for a strength test. Only the block with mixed soils meets the minimum standard strength of 2.5N/mm². Considering the results, and a careful fabrication process, we decide to try to use ISSBs in a pilot. I convince UN-Habitat to bring a Makiga expert on board for the production process to ensure the blocks are secure.

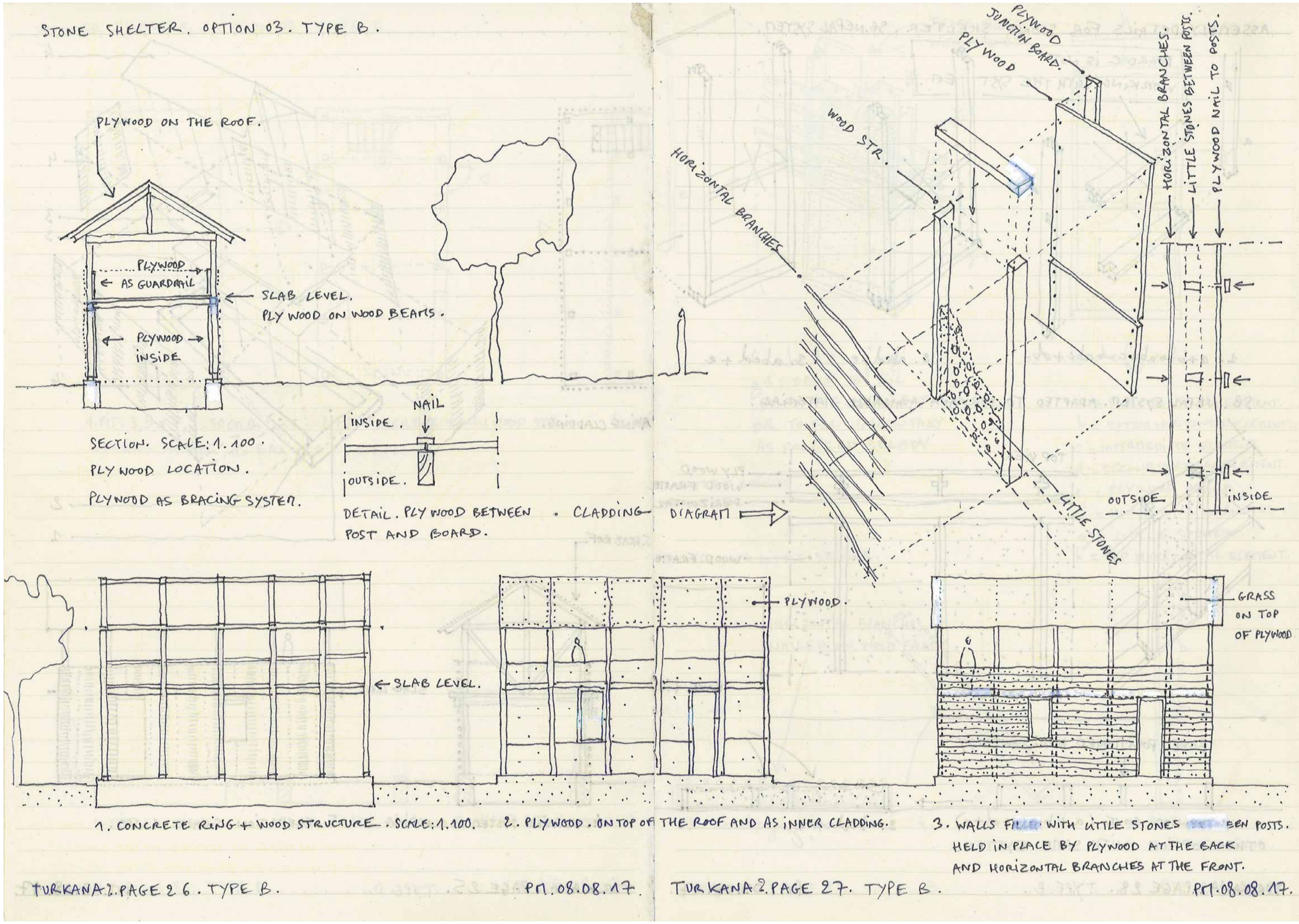
Lessons Learned. The Outdoor Room

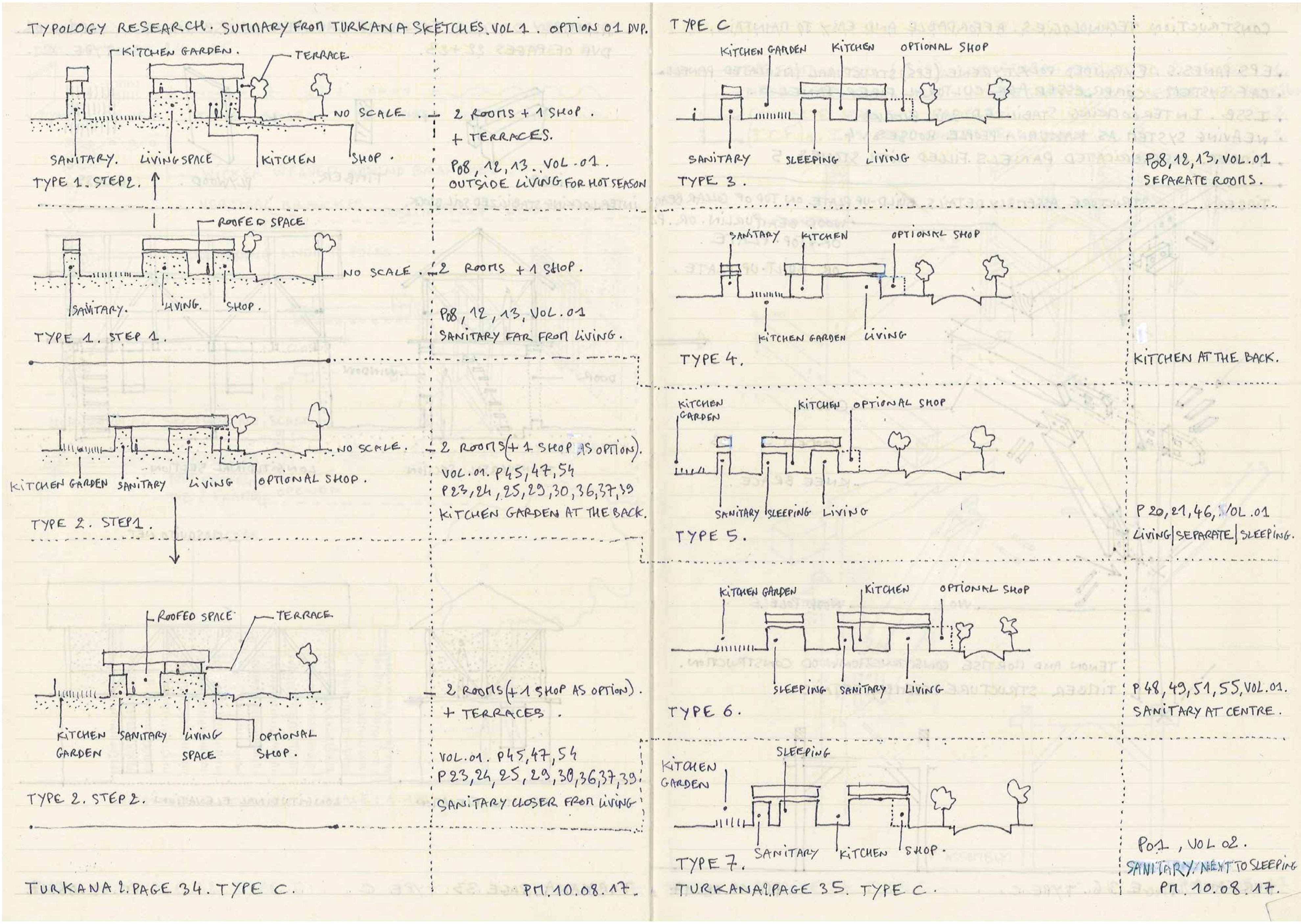
Traditional housing settlements in Eastern Africa consist of several houses organized in a nuclear structure, within a common outside living space. Therefore, the key finding of this mission is the discovery of the outside sleeping spaces which are unique to Turkana, as seen in Anne and Catherine's houses.

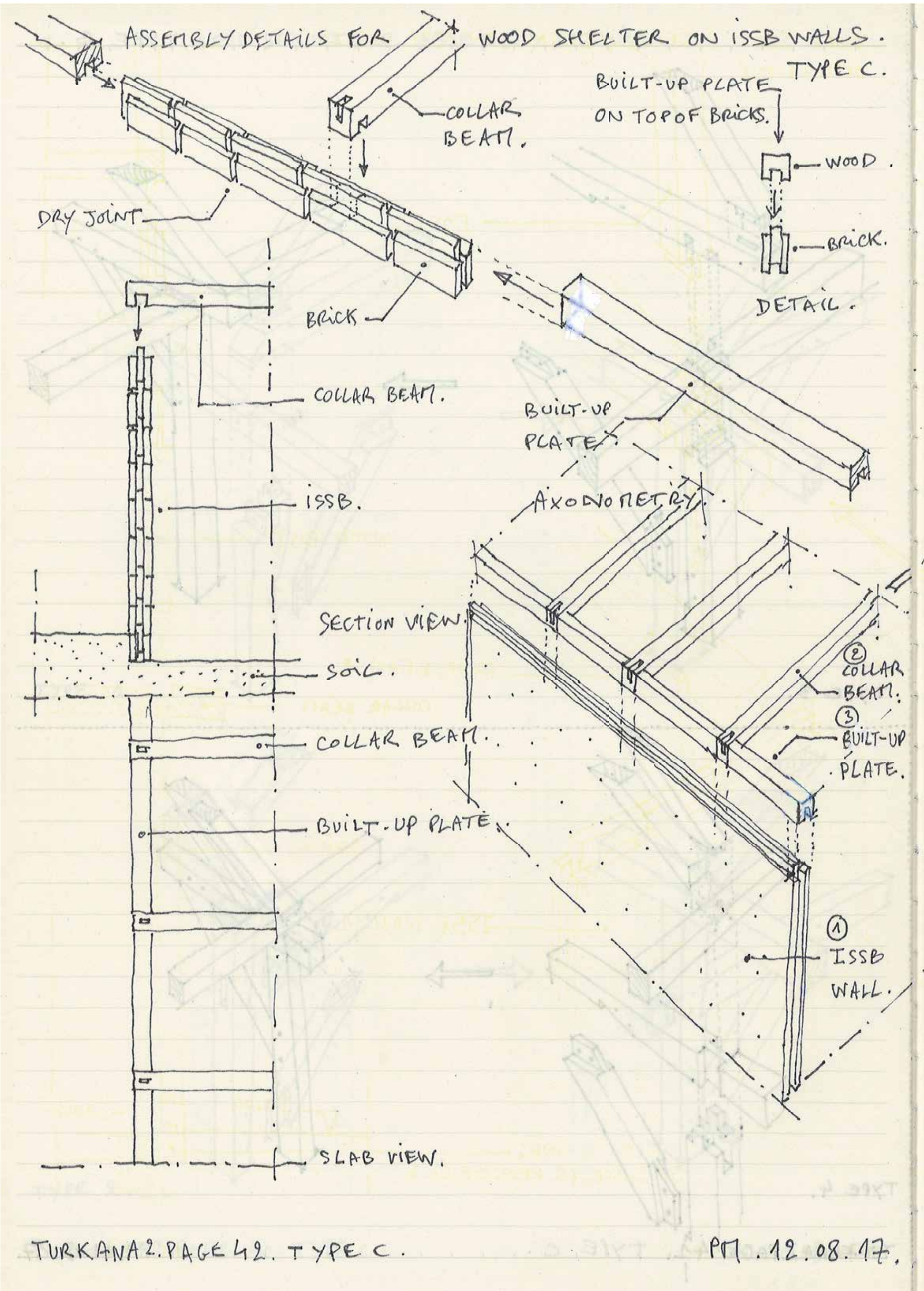
Following pages: extracts from sketchbook n°2. Outdoor sleeping space design

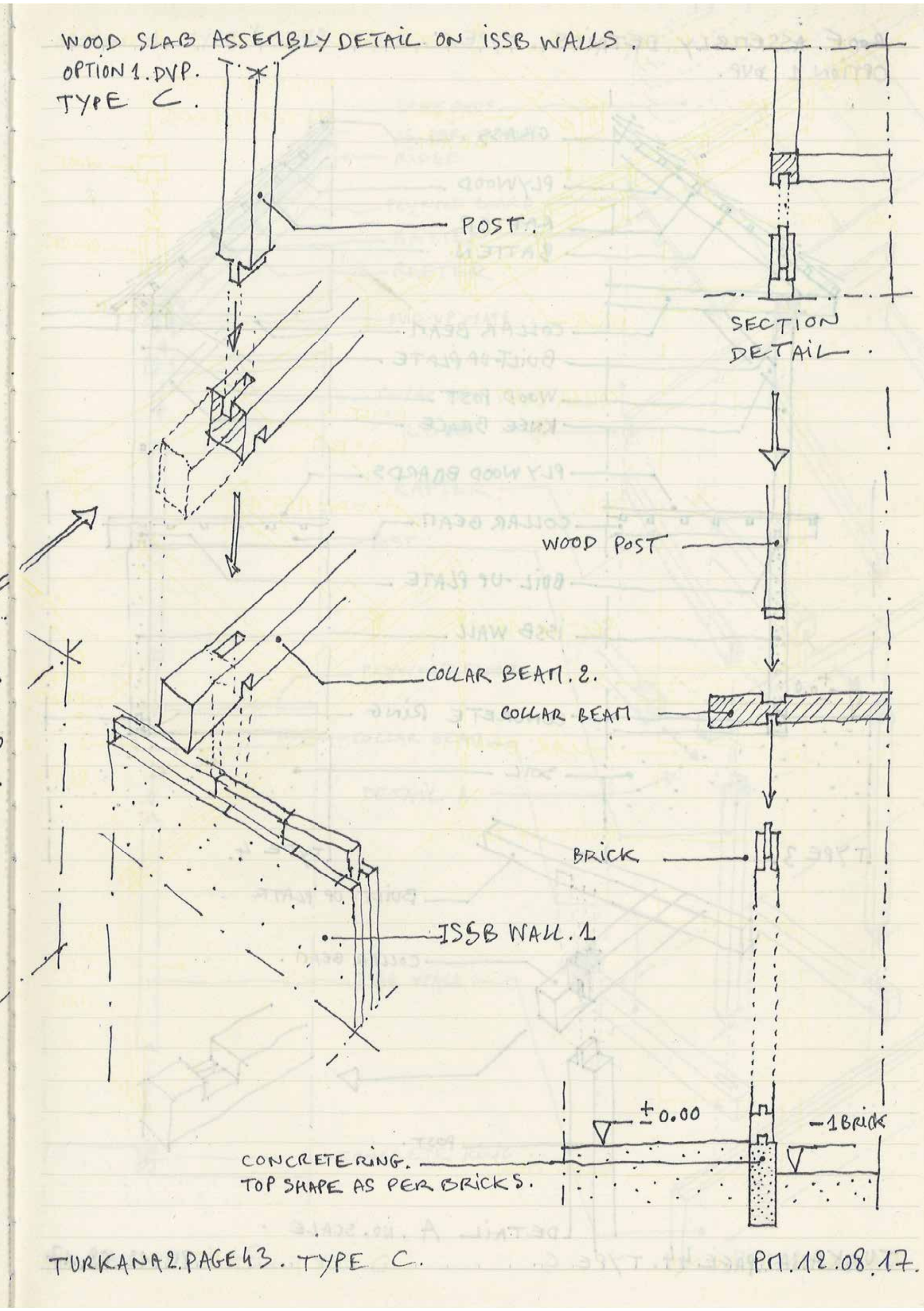

WOOD SHELTER ON ISSB WALLS . OPTION 01. TYPE C .
1. PIT. 3x7M. 50CM DEEP.
2. ISSB WALLS.
3. WOOD SLAB.
4. WOOD ROOF STRUCTURE.
4
3
2
1
1. PIT SECTION.
2. ISSB WALLS.
3. WOOD SLAB + WOOD POLES.
4. WOOD ROOF + GRASS.
5. ELEVATION. SCALE: 1:100
TURKANA 2. PAGE 22. TYPE C.
PM. 08.08.17
TURKANA 2. PAGE 23. TYPE C.
PM. 08.08.17

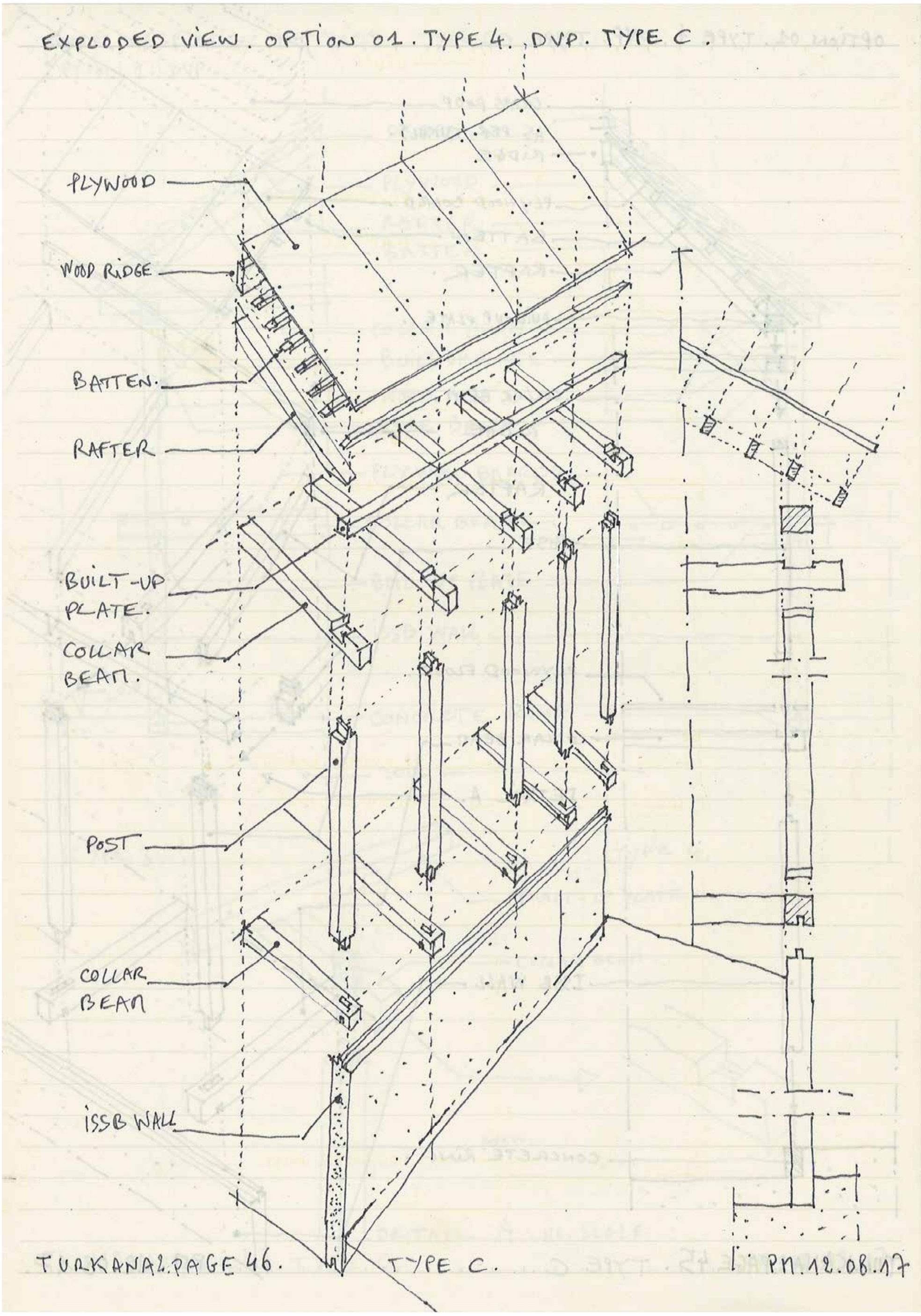

WICKER SHELTER . OPTION 02 . TYPE D .
7,5
3,5
1. PIT. 3,5 x 7,5 . 50 CM DEEP .
2+3. CONCRETE RING + WOOD STR.
4. WEAVING CLADDING.
WEAVING FACADE AS BRACING SYSTEM.
4
3
3
4
2
1
5. GRASS ROOF
SLAB LEVEL
1. PIT SECTION.
2. CONCRETE RING.
3. WOOD STR + WOOD SLAB.
4. WEAVING SYSTEM AS CLADDING.
5. ELEVATION . SCALE : 1.100 .
TURKANA 2. PAGE 24. TYPE D.
PM. 08.08.17.
TURKANA 2. PAGE 25. TYPE D.
PM. 08.08.17.


STONE SHELTER. OPTION 03. TYPE B.
PLYWOOD ON THE ROOF.
PLYWOOD AS GUARDRAIL
SLAB LEVEL.
PLY WOOD ON WOOD BEAMS.
PLYWOOD INSIDE
SECTION. SCALE: 1.100.
PLY WOOD LOCATION.
PLYWOOD AS BRACING SYSTEM.
NAIL
INSIDE.
OUTSIDE.
DETAIL. PLY WOOD BETWEEN POST AND BOARD.
CLADDING DIAGRAM
PLYWOOD JUNCTION BOARD.
PLY WOOD
WOOD STR.
HORIZONTAL BRANCHES
HORIZONTAL BRANCHES.
LITTLE STONES BETWEEN POSTS.
PLYWOOD NAIL TO POSTS.
LITTLE STONES
OUTSIDE.
INSIDE
SLAB LEVEL.
PLYWOOD.
GRASS ON TOP OF PLYWOOD
1. CONCRETE RING + WOOD STRUCTURE. SCALE: 1.100.
2. PLYWOOD. ON TOP OF THE ROOF AND AS INNER CLADDING.
3. WALLS FILLED WITH LITTLE STONES BETWEEN POSTS. HELD IN PLACE BY PLYWOOD AT THE BACK AND HORIZONTAL BRANCHES AT THE FRONT.
TURKANA 2. PAGE 26. TYPE B.
PM. 08.08.17.
TURKANA 2. PAGE 27. TYPE B.
PM. 08.08.17.

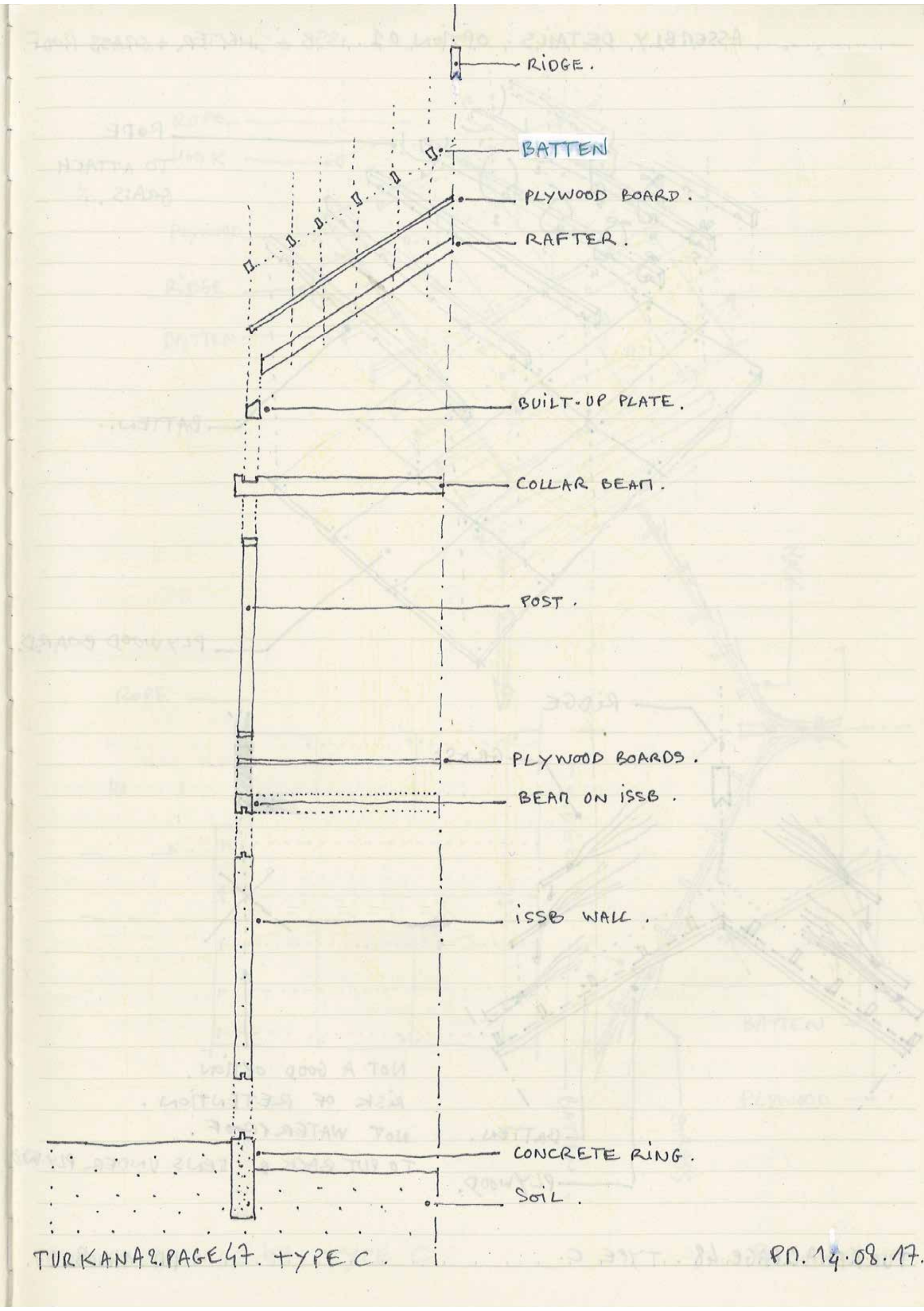

TYPOLOGY RESEARCH. SUMMARY FROM TURKANA SKETCHES. VOL 1. OPTION 01 DVP.
KITCHEN GARDEN.
TERRACE
NO SCALE
SANITARY.
LIVING SPACE
KITCHEN
SHOP.
TYPE 1. STEP 2.
2 ROOMS + 1 SHOP.
+ TERRACES.
P08, 12, 13. VOL. 01.
OUTSIDE LIVING FOR HOT SEASON
ROOFED SPACE
NO SCALE.
SANITARY.
LIVING.
SHOP.
TYPE 1. STEP 1.
2 ROOMS + 1 SHOP.
P08, 12, 13, VOL. 01
SANITARY FAR FROM LIVING.
NO SCALE.
KITCHEN GARDEN
SANITARY
LIVING
OPTIONAL SHOP.
TYPE 2. STEP 1
2 ROOMS (+ 1 SHOP AS OPTION).
VOL. 01. P45, 47, 54
P23, 24, 25, 29, 30, 36, 37, 39
KITCHEN GARDEN AT THE BACK.
ROOFED SPACE
TERRACE
KITCHEN GARDEN
SANITARY
LIVING SPACE
OPTIONAL SHOP.
TYPE 2. STEP 2.
2 ROOMS (+ 1 SHOP AS OPTION).
+ TERRACES.
VOL. 01. P45, 47, 54
P23, 24, 25, 29, 30, 36, 37, 39
SANITARY CLOSER FROM LIVING
TURKANA 2. PAGE 34. TYPE C.
PM. 10.08.17.
TYPE C
KITCHEN GARDEN
KITCHEN
OPTIONAL SHOP
SANITARY
SLEEPING
LIVING
TYPE 3.
P08, 12, 13, VOL. 01
SEPARATE ROOMS.
SANITARY
KITCHEN
OPTIONAL SHOP
KITCHEN GARDEN
LIVING
TYPE 4.
KITCHEN AT THE BACK.
KITCHEN GARDEN
KITCHEN
OPTIONAL SHOP
SANITARY
SLEEPING
LIVING
TYPE 5.
P 20, 21, 46, VOL. 01
LIVING | SEPARATE | SLEEPING.
KITCHEN GARDEN
KITCHEN
OPTIONAL SHOP
SLEEPING
SANITARY
LIVING
TYPE 6.
P 48, 49, 51, 55, VOL. 01.
SANITARY AT CENTRE.
KITCHEN GARDEN
SLEEPING
SANITARY
KITCHEN
SHOP.
TYPE 7.
P01, VOL 02.
SANITARY NEXT TO SLEEPING
TURKANA 2. PAGE 35. TYPE C.
PM. 10.08.17.


ASSEMBLY DETAILS FOR WOOD SHELTER ON ISSB WALLS.
TYPE C.
COLLAR BEAM.
BUILT-UP PLATE ON TOP OF BRICKS.
WOOD.
BRICK.
DETAIL.
DRY JOINT.
BRICK
COLLAR BEAM.
BUILT-UP PLATE
AXONOMETRY.
ISSB.
SECTION VIEW.
SOIL.
COLLAR BEAM.
BUILT-UP PLATE.
2 COLLAR BEAM.
3 BUILT-UP PLATE.
1 ISSB WALL.
SLAB VIEW.
TURKANA 2. PAGE 42. TYPE C.
PM. 12.08.17.

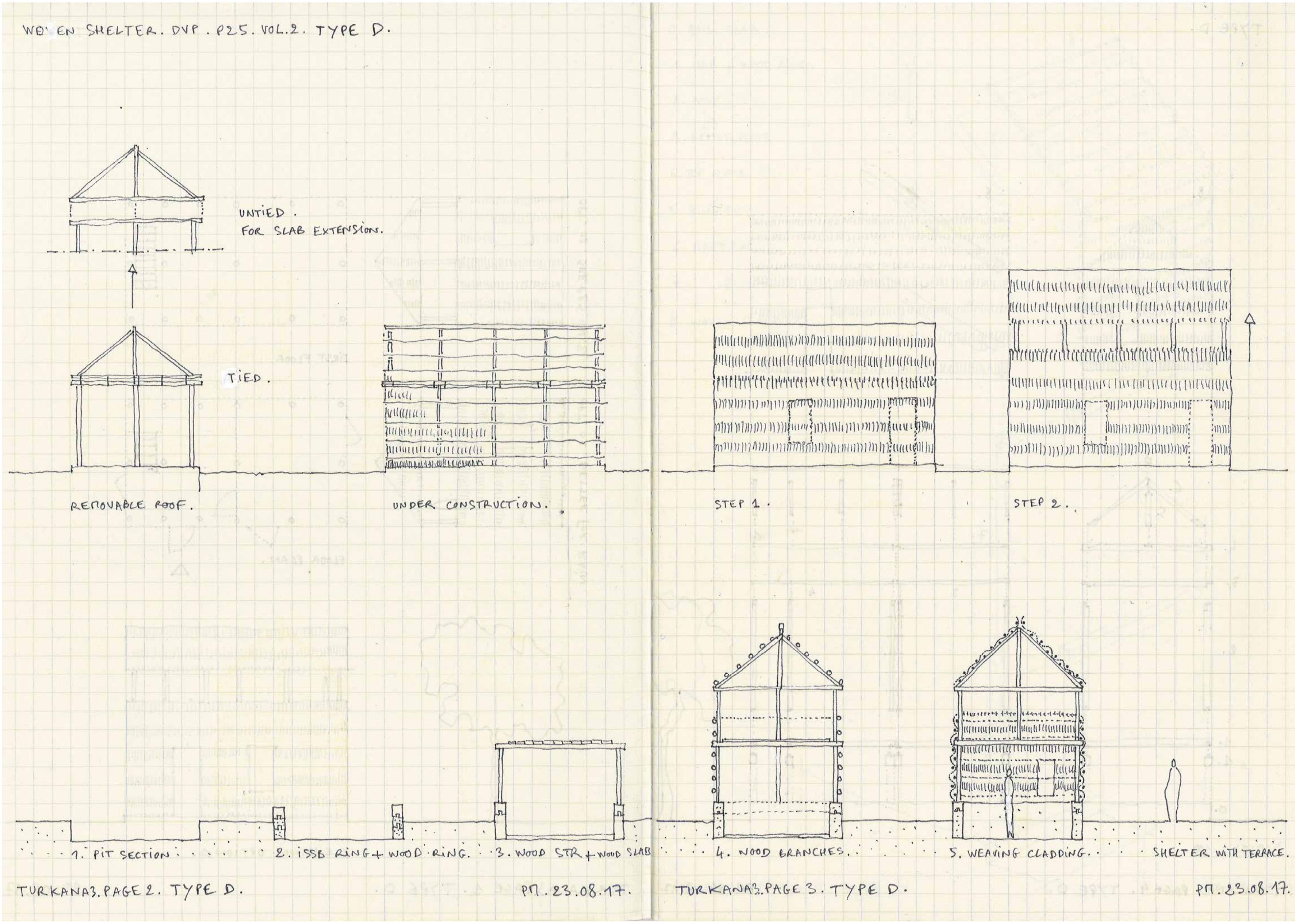

WOOD SLAB ASSEMBLY DETAIL ON ISSB WALLS.
OPTION 1. DVP.
TYPE C.
POST.
SECTION DETAIL.
WOOD POST
COLLAR BEAM. 2.
COLLAR BEAM
BRICK
ISSB WALL. 1
±0.00
-1 BRICK
CONCRETE RING.
TOP SHAPE AS PER BRICKS.
TURKANA 2. PAGE 43. TYPE C.
PM. 12.08.17.



EXPLODED ViEW. OPTioN 01. TYPE 4. DVP. TYPE C.
PLYWOOD
WOOD RiDGE
BATTEN.
RAFTER
BUiLT-UP PLATE.
COLLAR BEAM.
POST
COLLAR BEAM
iSSB WALL
TURKANA2.PAGE 46.
TYPE C.
PM.12.08.17



RiDGE.
BATTEN
PLYWOOD BOARD.
RAFTER.
BUiLT-UP PLATE.
COLLAR BEAM.
POST.
PLYWOOD BOARDS.
BEAM ON iSSB.
iSSB WALL.
CONCRETE RiNG.
SOiL.
TURKANA2.PAGE47. TYPE C.
PM. 14.08.17.


WOVEN SHELTER. DVP. P25. VOL.2. TYPE D.
UNTIED.
FOR SLAB EXTENSION.
TIED.
REMOVABLE ROOF.
UNDER CONSTRUCTION.
STEP 1.
STEP 2.
1. PIT SECTION
2. ISSB RING + WOOD RING.
3. WOOD STR + WOOD SLAB
4. WOOD BRANCHES.
5. WEAVING CLADDING.
SHELTER WITH TERRACE.
TURKANA3. PAGE 2. TYPE D.
PM. 23.08.17.
TURKANA3. PAGE 3. TYPE D.
PM. 23.08.17.

Turkana Culture and Shigeru Ban's Design

Mission M03. September 2017

Architecture from Lake Turkana

September 13th. We land in Lodwar, the capital of Turkana County. We take the dirt road to Eliye Springs, a village on the west bank of Lake Turkana, near the mouth of Turkwel river. During the ride through the dusty, sandy landscapes, it is hard to believe that we are moving closer to a water source, but a couple of tukuls covered with Makutis (weaved palm leaves) reminds us that we are approaching the "land of the palm trees". After driving for more than an hour, we reach the lake. The water is brown, and the lake appears endless. We climb a hill next to the shore and discover a village between palm trees. The view to the lake is magnificent. A woman is weaving some doum-palm leaves to cover her house, and she shows us the process. She uses no tools or manufacturing products, only her hands. She is so skilled at weaving that she can do it without looking (Fig. 17).

September 14th. We leave the lake and travel back to Lodwar. On the way, we have the chance to visit some huts under construction. Two women are weaving branches onto a skeletal frame, one standing on it while the other passes up the woven branches. At a second site, a woman shows us the palm leaf ring attached at the edge of the future roof. At the last site, a woman is weaving long, thick bales of doum-palm leaves onto a frame of branches (Fig. 18).
This experience is truly unique: we witness the full construction process of a typical house near the lake, except for the roof. It reminds me of the reed boats of the Uros people from Lake Titicaca.
While searching for the origin of construction techniques around the lake, I learn more about the El Molo people. They are concentrated in the Marsabit District

Fig. 17. A woman from Lake Turkana

on the southeast shore of Lake Turkana, between El Molo Bay and Mount Kulal. Their homes look exactly like the ones I have seen during this journey. I learn that 10 years ago, the last person able to speak El Molo language died. With a population of less than 400 people, they are near extinction, but the architecture

of these excellent fishermen is still a source of inspiration for all the others around the Lake[11].

Shigeru Ban's Presentation

September 21st. Shigeru Ban presents his initial design concepts for the shelters of Kalobeyei New Settlement in a video conference with UN Habitat colleagues based in Nairobi. He proposes three designs, all of which use simple construction techniques which he has previously tested[12]. Each consists of one 18m² room with a door, three windows and a roof:

Type A. The Paper Tube House. The design is similar to his Kobe Shelters project from 1995, but there is a slight difference: the paper tubes for the cladding are woven together with rope, like the branches of the Turkana huts. He shows that we can use traditional techniques in contemporary architecture, and the design demonstrates his consideration of the sculptural structures made by the Turkana people.

Type B. Inspired by his Nepal Shelters project. In May 2015, a month after the terrible earthquake in Nepal, he visited the site and discovered brick rubble from houses that had been destroyed. He then came up with an ingenious design idea: a wood frame filled with brick rubble. This was necessary because masonry walls are not earthquake proof, since they have no resistance to lateral forces. When the design for the more flexible wooden structure was tested in Japan, the bricks cracked and the wooden frame was moving, but its structural integrity was not affected. The proposed design raises an important question from UN-Habitat:
Why build such a structure in Turkana, a non-seismic zone?
Shigeru Ban explains that it is easier to build than a masonry wall, and it is also safer because the brick acts only as a filling materials: should the masonry work fail, the structural integrity of the house will not be affected.

Type C. A CEB House inspired by Shigeru Ban's shelters in Kirinda, Sri Lanka. This construction technique is very common in Africa, if suitable soils are available as it is an efficient and cheap way of building houses. Since we have seen the results of the first UN pilot made of CEBs, we can use this technique with a better understanding of the challenges and opportunities it presents.

UN-Habitat ask Shigeru if he will consider designing a 2-storey house.
"*No*," he tells them, "*It is too risky and too expensive to build a 2-storey house in this context. With the limited budget per household, and considering that it needs to be replicated by people who may not be technically skilled, the design should be kept simple.*"

Fig. 18. Turkana huts under construction near Lake Turkana

At the end of the presentation, Shigeru announces that we will design a fourth option inspired by South Sudanese architecture, a proposal that will be the result of my research on their habitats.

Improvement of the Design

During the presentation, Shigeru explained the necessity of building simple structures, focusing on their structural stability, cost efficiency, and potential to create employment opportunities by using local building materials.

Yuka Terada from UN-Habitat has some questions:

Ventilation and Cooling. Could the shelters have a slightly wider, overhanging roof to provide more shade? Could you design a higher pitched roof to improve ventilation and avoid roof damage from strong winds? In case of a dust storm, is there a strategy to prevent dust from entering through the ventilation holes? Could we consider more windows to increase cooling?

Internal partition wall. Are there plans to incorporate partitioning walls in any of the designs?

Structure and Roofing. Are there any methods to ensure the foundation construction is stable? How can the design protect against termites? Can we check the availability of grass for thatched roofs?

Cooking. How can we make allowances for the construction a semi-outdoor kitchen? Could it be designed as an extension?

Incremental design strategy. Does the design enable potential future extensions demanded by growing families? Is it possible to design a modular system from the outset that would permit an extension?

Local skills and economic development. Should we consider developing small factories to manufacture building materials of the chosen type e.g. a paper tube factory for Type A, a wooden frame factory for Type B, or an ISSB factory for Type C?

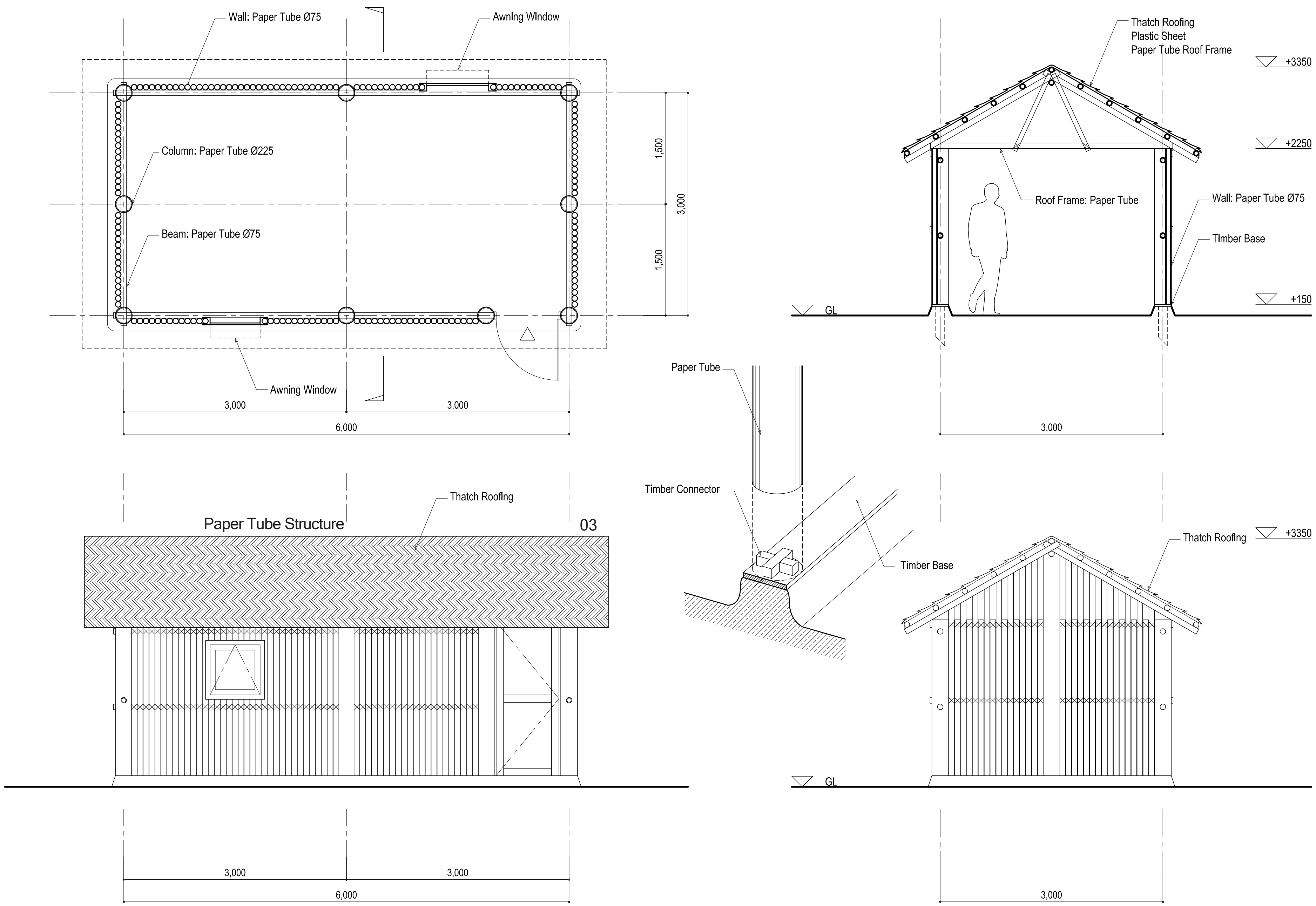
Risk assessment and quality assurance. Since we aim to create job opportunities through the housing construction project, should we think about a construction and building association to carry out quality control during construction? Is it possible to develop a manual on how to identify quality materials, and/or how to monitor the construction process?

Two years later, and after seven different pilot houses tested, I will finally set-up a Manual of our latest pilot that refers to Yuka's requirement (part 2 of the book).

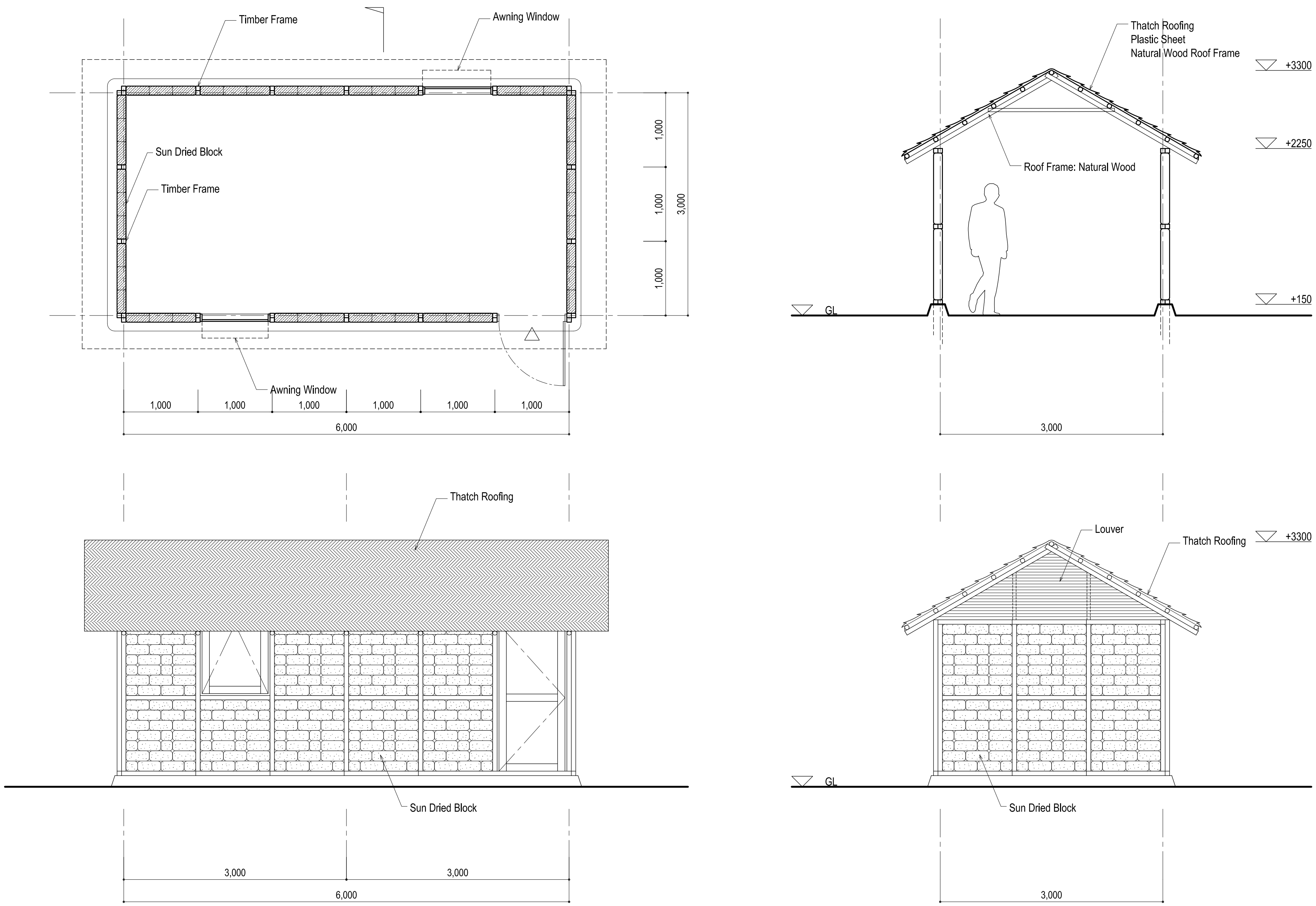
Lessons Learned. Tradition and Modernity

When comparing the Kalobeyei structures and the ones from Lake Turkana, I realise that the technique is almost the same, except for the use of palm leaves near the lake. The composition of the structures is strongly impacted by the land and its available resources. Houses are built using materials gathered from the surrounding environment, and nothing more. The Paper Tube House proposed by Shigeru Ban may appear far from a traditional Turkana shelter in terms of materiality, but the woven paper tubes are an homage to their culture.

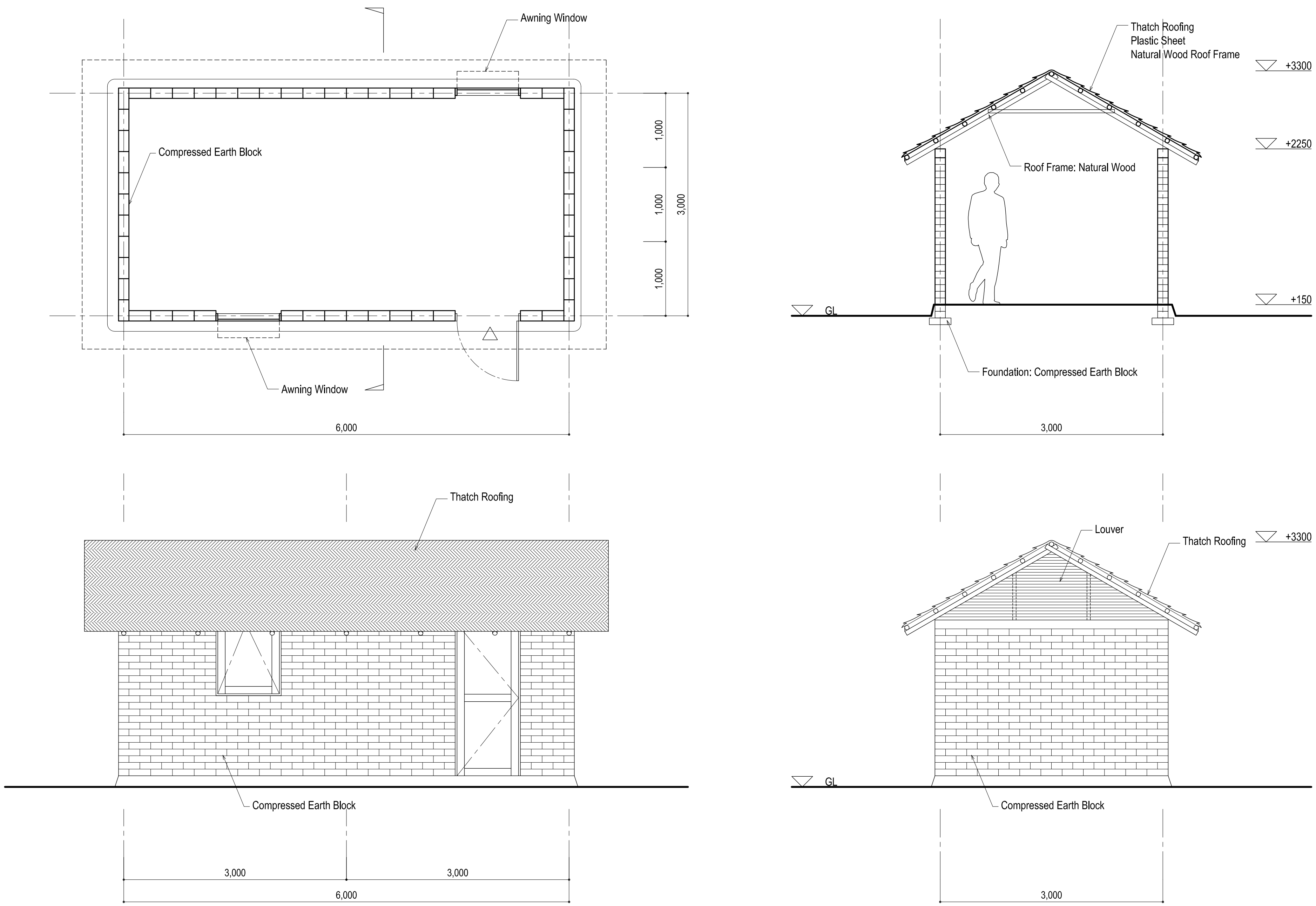
Following pages: extracts from Shigeru Ban's proposal. Types A, B and C



Paper Tube House layout. Not to scale. VAN drawing



Timber Structure House layout. Not to scale. VAN drawing



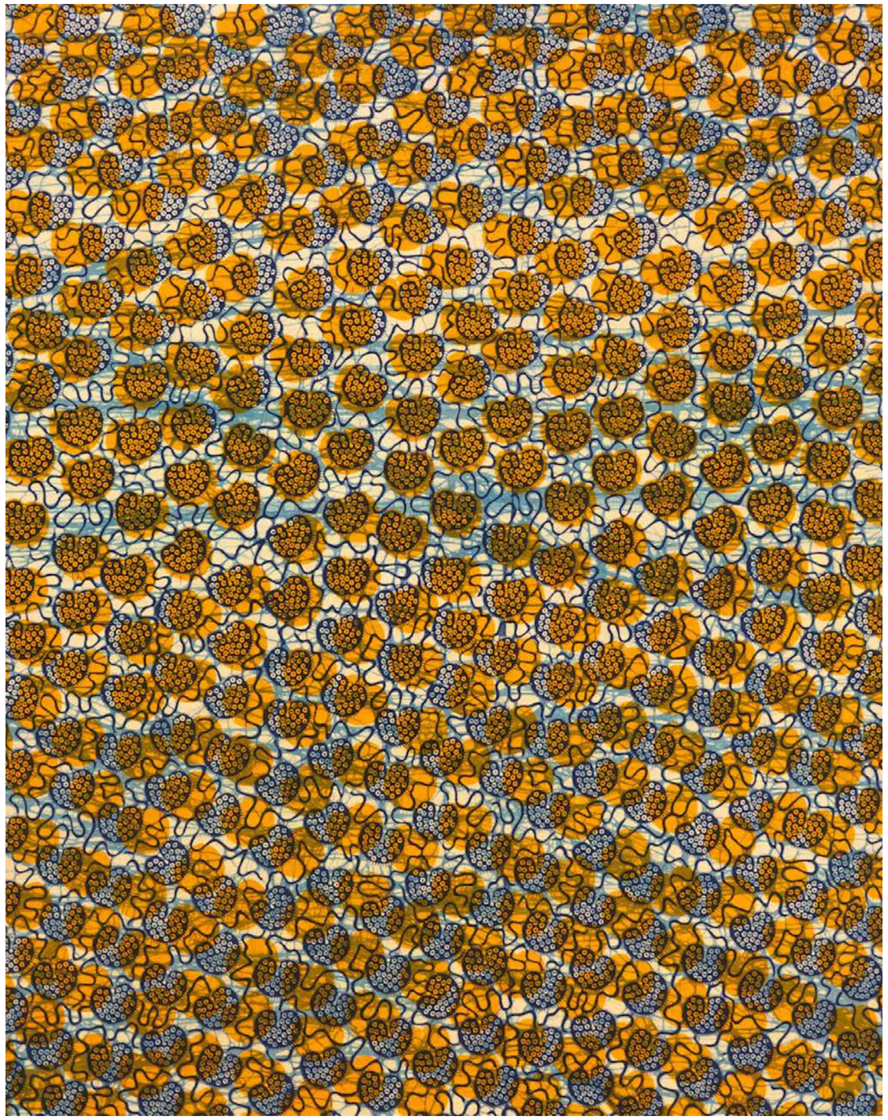
CEB House layout. Not to scale. VAN drawing

Internal Partitions – Ideas

October 11th. I return to Kakuma to look for skilled personnel for the pilot construction, and visit Don Bosco Technical Institute. Father Jose Padinjareparampil describes the institute under his direction: "We have been offering training in different trades that include welding and metal fabrication, fitter turner, engine rebuilding, carpentry and joinery, masonry/brick laying, plumbing, electrical, motor vehicle mechanics, driving school, typing and secretarial, art and design, tailoring and dress making, cabinet making, computer training and literacy and numeracy (…) Our vision is to be a centre of hope and transformation that serves the youth in the camp and the local community to be self-reliant and regain their dignity under the charismatic style of Don Bosco that advances justice, peace and integrity of creation."[13]

These words give me hope that we will find people who will be keen to work with us. Later, on the first day of construction works, we will find that many want a job, but few have sufficient skills for basic house construction. When visiting the workshops, we see paper clothes and dress-making patterns. These give me an idea to use *vitenge* – colourful pieces of fabric common in Africa – as partitions in the houses (Fig. 19 and 20).

"Kitenge (plural *vitenge* in Swahili; *zitenge* in Tonga) serve as an inexpensive, informal piece of clothing that is often decorated with a huge variety of colours, patterns and even political slogans. (…) The printing on the cloth is done by a



Yellow / Cream Shells
Fig. 19. Original, African wax print fabrics (Source: KitengeStore.com)

Green/ Red Shells

Fig. 20. 'Paper Dress' by Denise from Don Bosco workshop

traditional batik technique. They are known as wax prints and the design is equally as bright and detailed on the back side of the fabric. (…) Many of the designs have a meaning. A large variety of religious and political designs are found as well as traditional tribal patterns." [14]

In the afternoon, we drive to Kalobeyei Settlement, Neighbourhood 1, to conduct our last interviews with South Sudanese refugees about their former homes. Suddenly, we see a small sand tornado that moves quickly between the T-Shelters and disappears! I learn that it is a common phenomenon here in Turkana.
Little harm has been done this time, but sometimes these small tornadoes can be so strong they blow off the corrugated iron roofs. I am warned that our structure will have to be strong. I think of the kitenge, and the questions from UN-Habitat: *How can we prevent blown dust from entering the houses?* Obviously, a kitenge would be too fragile to protect the house on the outside, but it could be helpful inside.

Back in Nairobi, I research ways to protect the house. The three designs all have louvres at the top of the short façades, which face the prevailing wind direction. For ventilation purposes, louvres are simple and efficient, but how can we stop dust from getting in? I sketch some windows on rooftops and try to imagine how we could use them. These first drawings are not so effective, but it will give us inspiration on the construction site that will lead to a better solution.

South Sudanese Survey Completion

November 3rd. David shares the last of the finished questionnaires that we initiated during my mission in August. We interviewed a total of 37 refugees from South Sudan. The interviewees are mainly Lotuko people, a tribe close to the Lopit and the Toposa. Most crossed the Kenyan border to escape the civil war. I begin by looking at the data from each participant: their identity, location in the camp, community, which example from my report do they say resembles their former habitat, their description of construction techniques, living conditions in their current T-Shelter, and which of Shigeru Ban's housing designs they prefer for living, and for business. I then analyse the data, categorising information about:
- Tukuls from South Sudan: Location, type of construction, material sources, construction techniques
- T-Shelters from Kalobeyei Settlement: What challenges do occupants face?
- Refugee thoughts on Shigeru Ban's designs: What is the most attractive type for living? And for business?

Tukuls from South Sudan

When we show the interviewees pictures from the report, the majority recognise the Dinka and Nuer constructions.

When we enquire about the social customs in their villages, many confirm that it is women who stay in huots with small animals, while men sleep in luaks with their cows. We can also easily observe the distribution of houses from outside, as the size of a luak is almost twice that of a huot.

The survey confirms that most of the community are sharing the same type of architecture as described previously, except for those living in remote areas, like the Kachipo, Toposa and Lopit peoples.

The climate conditions and the geographic location define the style of each tukul. In terms of protection from rain, the most relevant example is the Lopit huts, with their thatch roof touching the ground. The low roofing also protects the bottom of the walls from erosion, further preventing water from getting into the house.

We have found that when people are far from town, they use materials gathered from their surroundings for construction. When they are in town they buy most materials, whether traditional or modern. Regardless of where they procure materials, all build using traditional methods. In the capital of Juba, we still find entire neighbourhoods of tukuls. The thatched roof is replaced with corrugated iron, but the round shape of the walls and the conical roof is preserved.

A typical hut is built in the following sequence: walls, roof, door and windows. The walls and floor are then daubed with mud. The walls consist of a series of acacia poles with mud or mud bricks. When building in town, cement may replace mud. The roofing is a thatch made of poles and reed branches, or a timber structure with corrugated iron sheets. The door is either a simple bamboo screen or a timber door. Most of the huts have no windows. Traditionally, the men build the structural parts and the women collect materials and apply finishes like daubing and painting the mud walls.

As mentioned previously, the location influences the style of architecture. By the Nile they build with Sisal or reeds, and in the mountains, they use branches and grass. Architecture is directly inspired by the surrounding environment.

T-Shelters from Kalobeyei Settlement

When we ask residents of Kalobeyei Settlement about the main issues they face, most mention natural elements like wind, dust, and floods. Thieves are also a problem: it is very easy to cut the tarpaulin that covers the T-Shelters. Another factor is the danger of scorpions and snakes that are carried into the houses by the floods. This highlights the importance of using a resilient cladding system, which will not be so easily damaged.

Refugees' Thoughts on Shigeru Ban's Designs

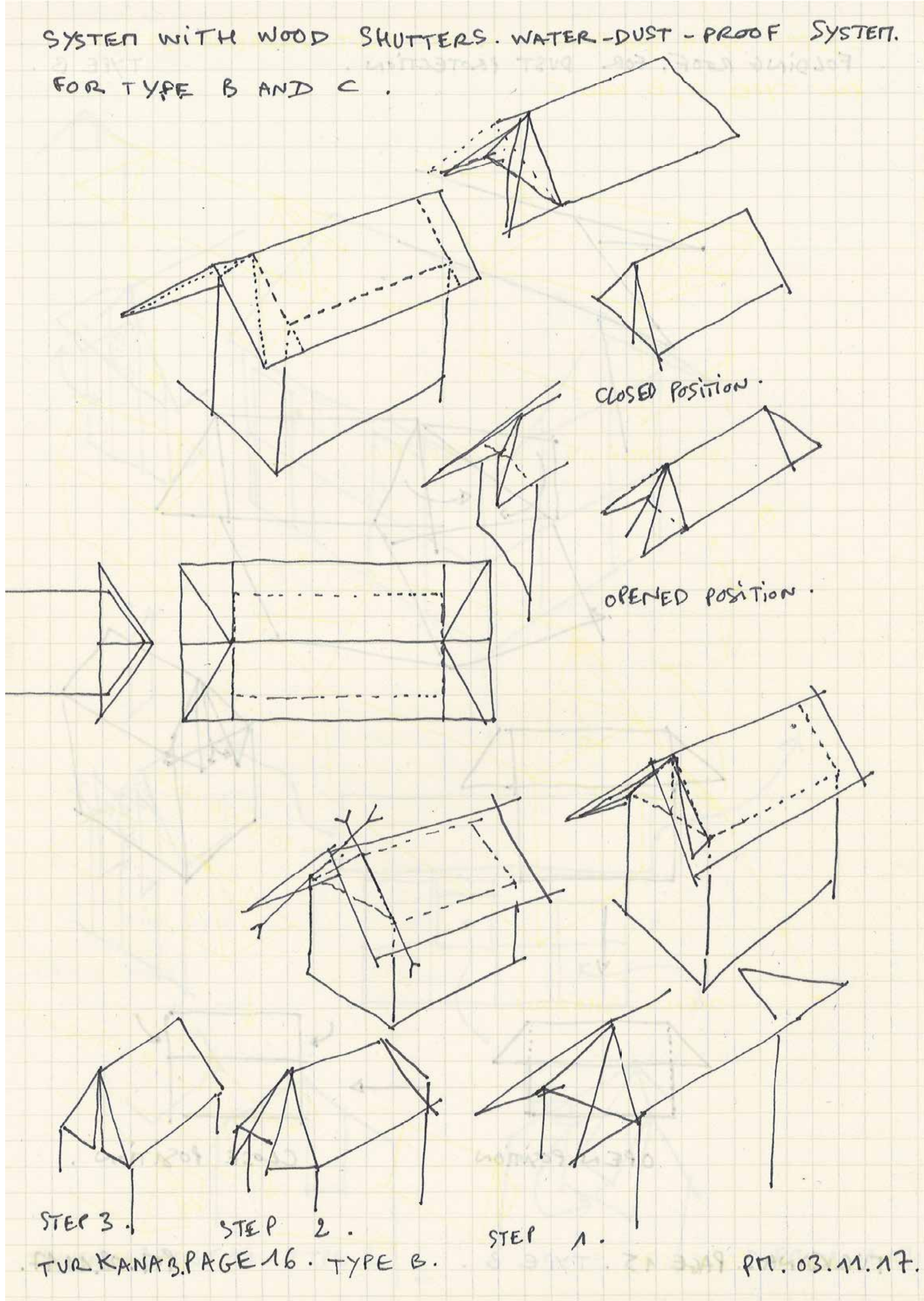
We show refugees the three proposals, and ask them in which type they could see themselves living in. They consider all housing types, but most choose either the CEB or a stone house. Most believe that the Paper Tube House (Type A) is too weak, but find the idea of paper tubes intriguing. It seems they favour housing which seems more secure, offering a sense of safety that is not only physical, but also psychological. It strikes me that it would be interesting to ask them the same question standing in front of the built pilots, to see if they would change their mind when seeing the real thing.
When we discuss which type would be best for family businesses, their responses differ greatly. The Paper Tube House is an attractive option, probably because they recognise potential uses for the technology: One refugee even suggests starting of a paper tube factory. In the end, however, Type B and C houses are selected more often. The refugees mention that it would be a good idea to start a cooperative for ISSBs and burnt bricks. One refugee is also thinking of using small stones gathered from the ground as a cladding material.

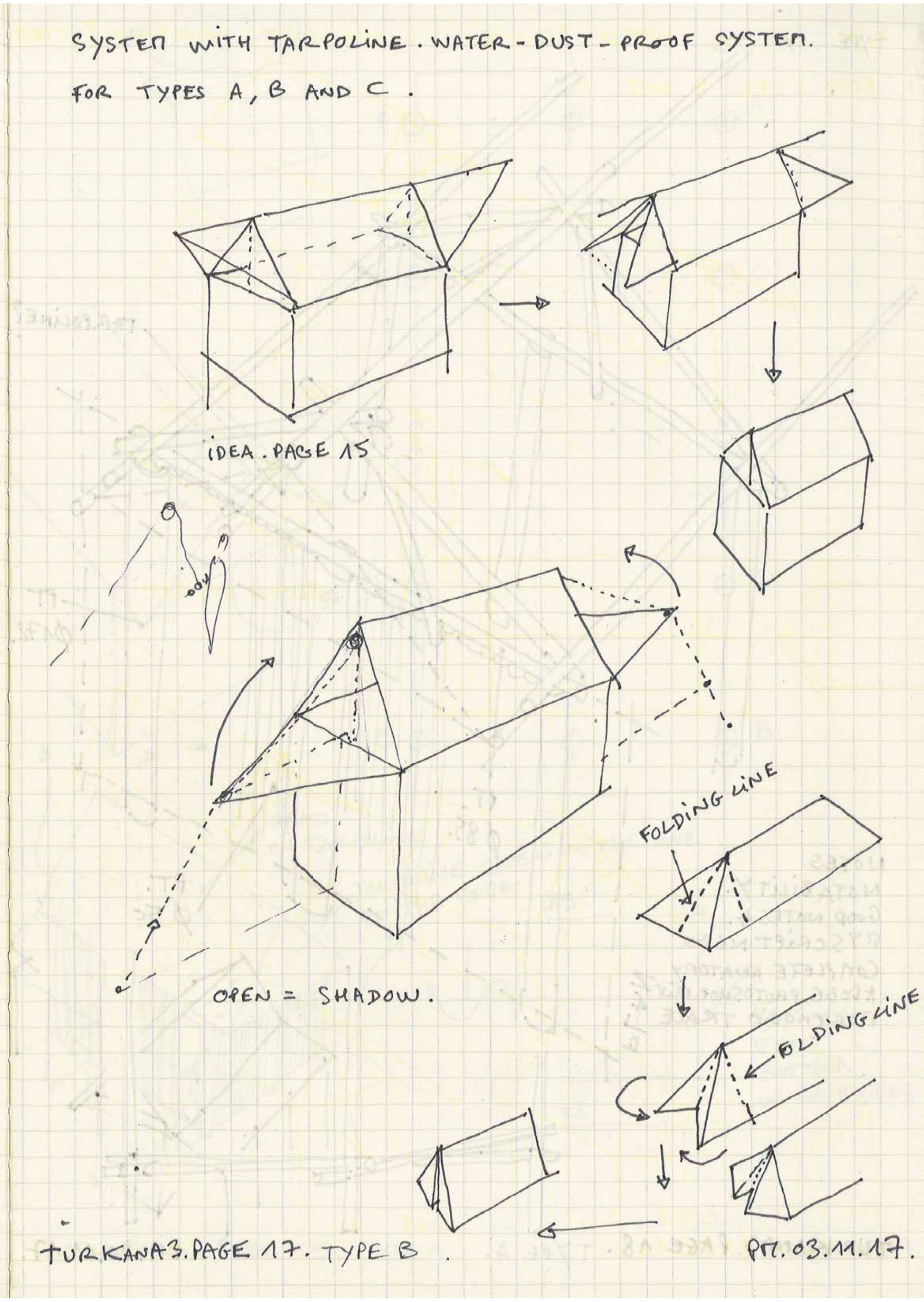
November 22nd. I send the report to Shigeru Ban.

Lessons Learned. Architecture as a Vector for Economic, Social, and Cultural Exchange

The question of employment is probably the most interesting and relevant. As Shigeru Ban said during his visit to the camp, it is important not to only build houses, but also to provide job opportunities for refugees and Turkana people. UN-Habitat also sees a chance to reconcile these communities, to reduce existing tensions and encourage collaborative business activities and commercial exchanges. This may offer some hope to refugees, and to Turkana people who are willing to participate to the development of their county. Architecture could also support artistic expression, providing a way for each community to share their culture with others.

Following pages: extract from sketchbook n°3. Dust proof system research


SYSTEM WITH WOOD SHUTTERS. WATER-DUST-PROOF SYSTEM.
FOR TYPE B AND C.
CLOSED POSITION.
OPENED POSITION.
STEP 3.
STEP 2.
STEP 1.
TURKANA3.PAGE 16. TYPE B.
PM. 03.11.17.


SYSTEM WITH TARPOLINE. WATER-DUST-PROOF SYSTEM.
FOR TYPES A, B AND C.
IDEA. PAGE 15
FOLDING LINE
OPEN = SHADOW.
FOLDING LINE
TURKANA3.PAGE 17. TYPE B.
PM. 03.11.17.

Preparing for Construction

Mission M05. Nov./Mid-Dec. 2017

Paper Tube Exploration before Production

While I am analysing the survey, I start to think about the logistics of building the pilot shelters, and what will need to be done in preparation for the construction scheduled for mid-December.

October 15th. Adarsh sends me a quote for the paper tubes, based on their length and the sections available. I ask him to test a varnish treatment on the paper tubes, using a locally available varnish, to make them waterproof. On November 8th, I receive pictures of the first test, but the results are inconclusive. The varnish is too opaque, and Shigeru Ban wants to keep the paper craft visible.
I am also reviewing the drawings of the former proposal, while researching potential assembly details. I redistribute the columns in the design, to align them with the trusses and simplify their assembly on site. To ensure a strong connection between the paper tube columns and the foundations, I slot the columns into the natural wooden poles used to anchor the house. I then fill them with soil available on site, until the soil fills the bottom 1m of each column. I also add a porch to the design, for increased shade around the house.

November 20th. Yasunori Harano, director of VAN, sends me a new set of drawings, along with advice based on previous construction experiences on site. The set includes plans, a lateral section, a paper tube column specification drawing for production purposes, and pictures to show how to attach the trusses together.

November 23rd. Adarsh and I meet at his factory to review the details, and determine the quantity of paper tubes required for construction. I bring the hole-saw to make holes in the columns, specific tool usually used by VAN.. Adarsh shows me the latest varnish test - the appearance is good! We can now move forward with the production of paper tubes.

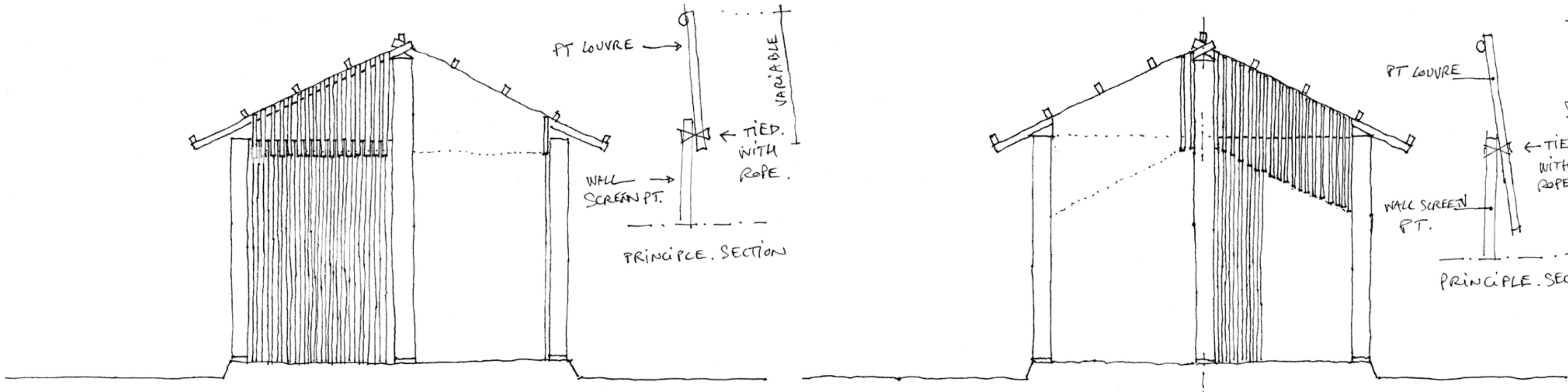


Fig. 21. Type A. Louvre design options

Ventilation System Research

In the same week I redraw the current section of the Paper Tube House, guided by the pictures sent from Tokyo of the trusses held together with ropes. We still need to figure out exactly how we will connect the louvres to the top trusses on the shorter façade, as they are not on the same plane. We find two options, and decide the final detail will be done on site. We will manufacture tubes that are long enough to suit both construction options, and test both (Fig. 21).
We have to find a way to prevent sand from being blown into the house through the louvres during wind storms. My previous idea of roof windows will not work for the Paper Tube House. Shigeru Ban suggests we reuse an idea of his from the Kobe houses: a tarpaulin canopy constructed in front of the louvres that can be folded when necessary, using a technique similar to origami (Fig. 22).
Later we will be forced to adopt a more basic detail due to a lack of tools available on site.

Reviewing Details before Construction

November 20th. While preparing for the construction of the Paper Tube House, I convince Yuka to hire a specialist to teach the host and refuge community how to make ISSBs. Today Peter Simiyu, an instructor from Makiga, arrives in Kakuma. With support from Peace Winds Japan[15], he sources suitable soil to produce ISSBs. Unfortunately, due to a lack of preparation on site, training and production is much slower than expected.

December 4th. I arrive in Kakuma and we visit the ISSB production site, which has already made many blocks. Peter explains that the process has four steps:
1. Collect locally available soil, sift to remove bigger aggregates
2. Mix together 95% sifted soil and 5% cement, then add water
3. Using an ISSB machine, compress the mixture into a metal mould

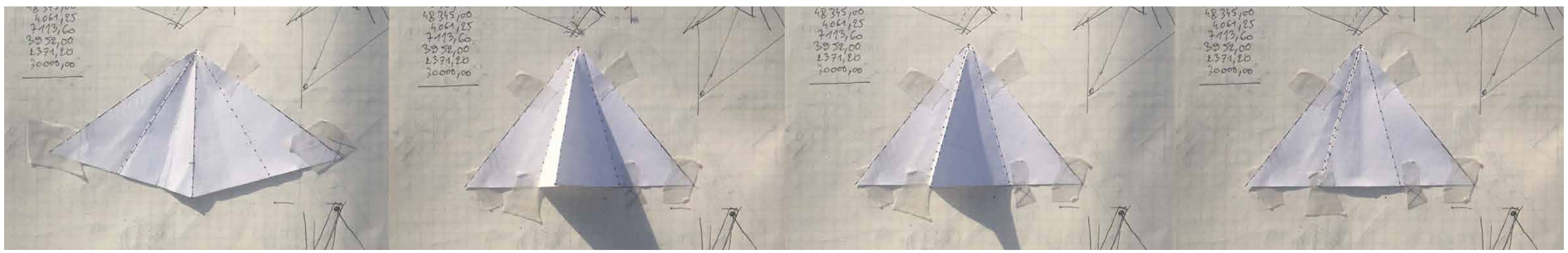


Fig. 22. Type A. Dust proof system research

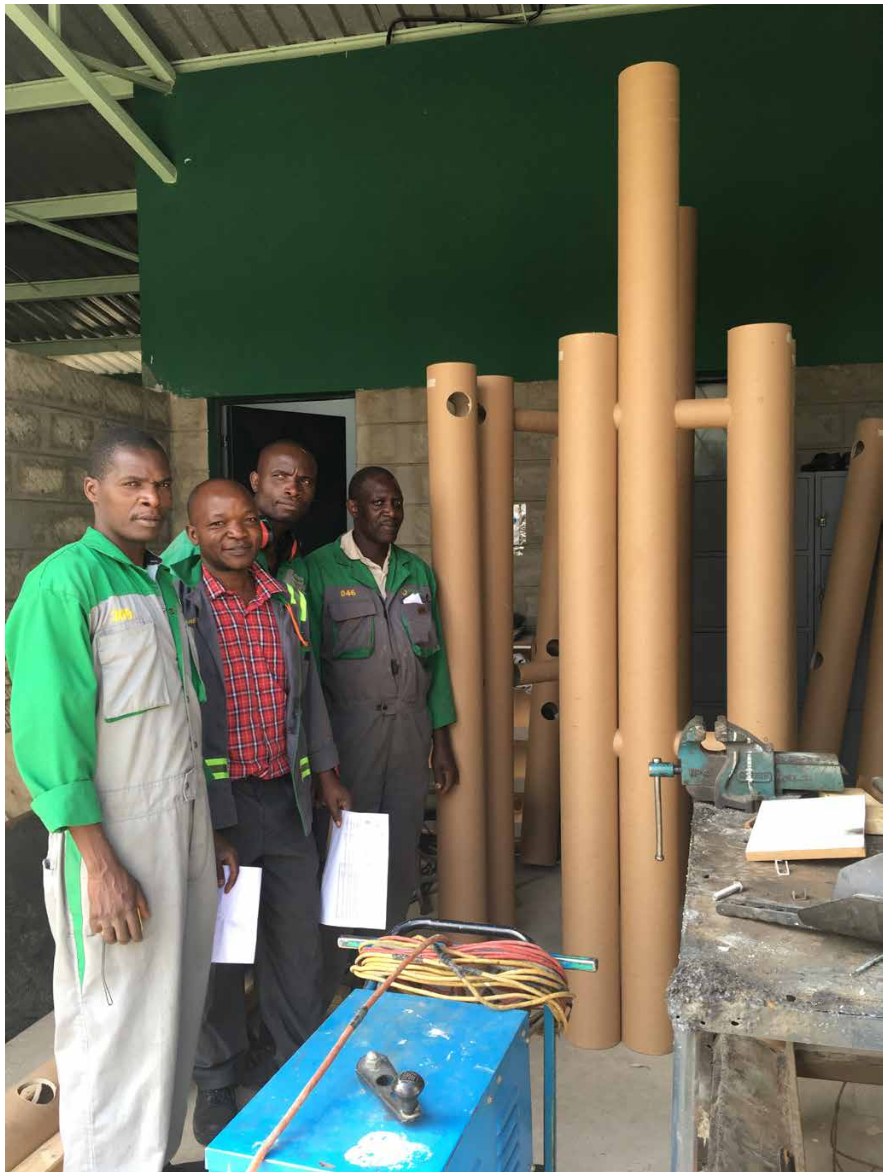


Fig. 23. Type A. Beam/column assembly test at Statpack factory. From left: Godfrey, Arthur, Julius and Musa

4. Remove blocks and allow them to dry for fourteen days, wetting them routinely with a watering can to prevent cracking

December 5th. I go over the finer construction details of the pilots. We decide to cover the foundation board and poles with used motor oil to protect the wood

from termites. For the roof, tarpaulin will be placed under the purlins, and corrugated iron on top. The idea is to use the tarpaulin to create an air gap which will insulate the house from the heat generated by the iron roof.

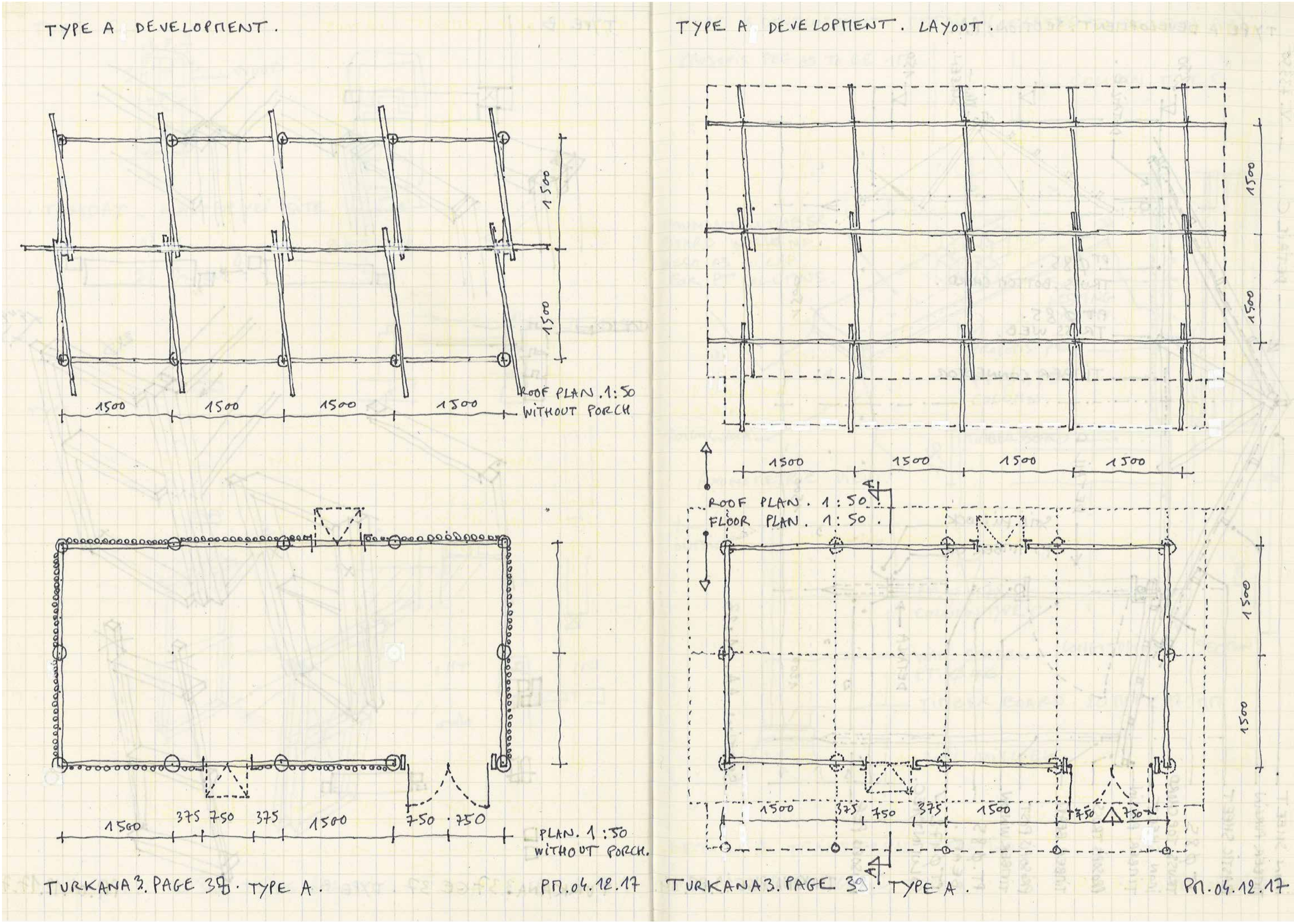
Type A. We will assemble the structure next to the foundations, and slot it into the poles afterwards. We will also need to phase the assembly to ensure we can successfully enclose the structure. We consider leaving a hole on one side to assemble the last beam.
Later, we will find that the hole was not necessary because the paper tube structure is elastic enough for assembly.
Type B. The timber frames and burnt bricks should all be made locally to create business opportunities for residents. The team on the ground will organise production.
Type C. We agree to use five rows of ISSB sitting on a bed of mortar for the foundations of the Type C House. The wooden ring beam will be made of two sections of 2'x 3' and one of 2'x 2' timber. I propose that we use the same principle of wood interlocking with ISSB blocks for the window and door frames.

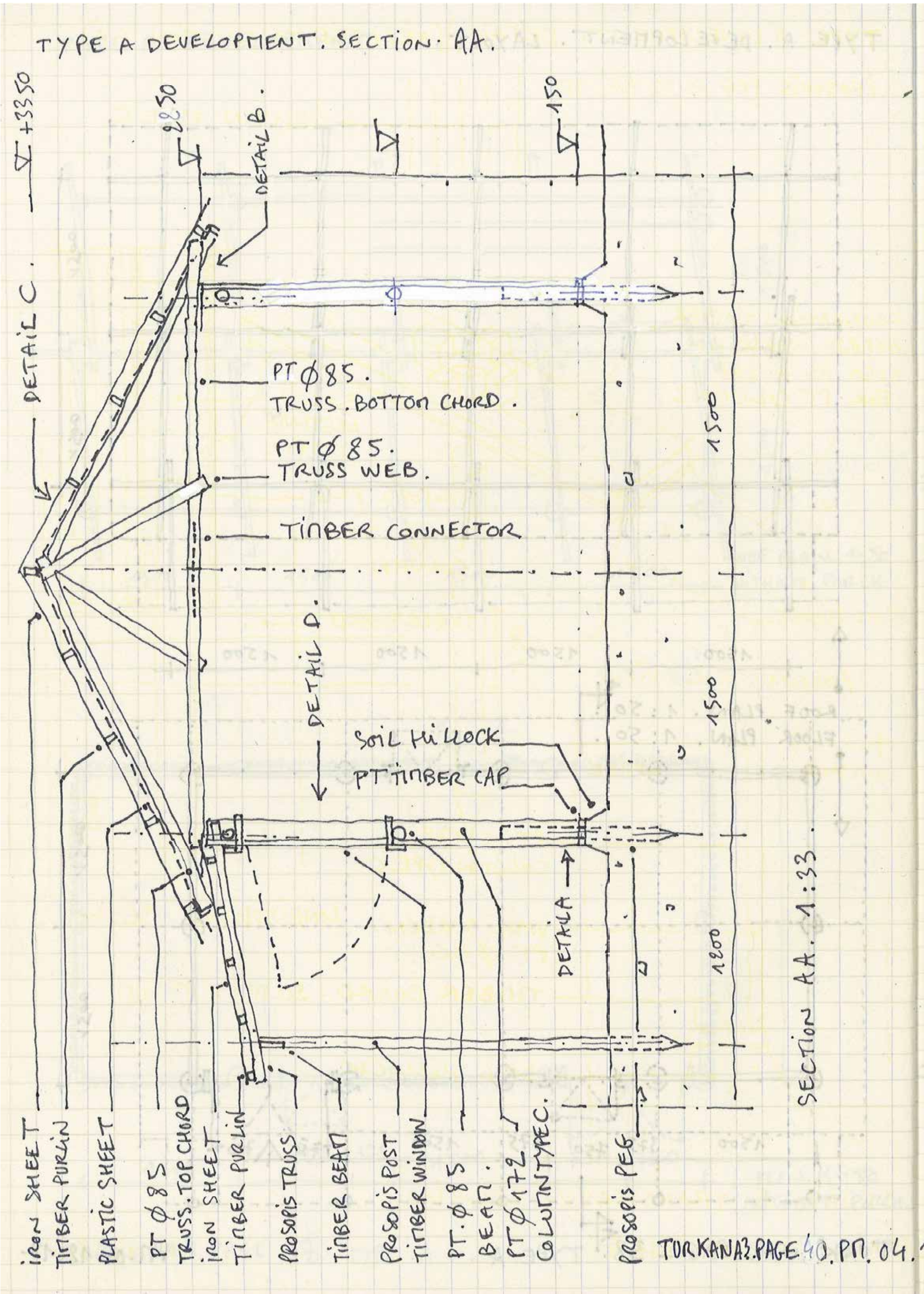
December 7th. Back in Nairobi, I check on the production of the paper tubes at the Statpack factory. One team is supervising their fabrication, while others are soaking the tubes in a long metal receptacle filled with clear varnish. Adarsh shows me the beam-column assembly test. I explain the importance of drilling holes into the paper tubes before varnishing them, in order to ensure they are fully waterproof, and furthermore the importance to redo the assembly test afterwards with the varnished paper tubes (Fig. 23).

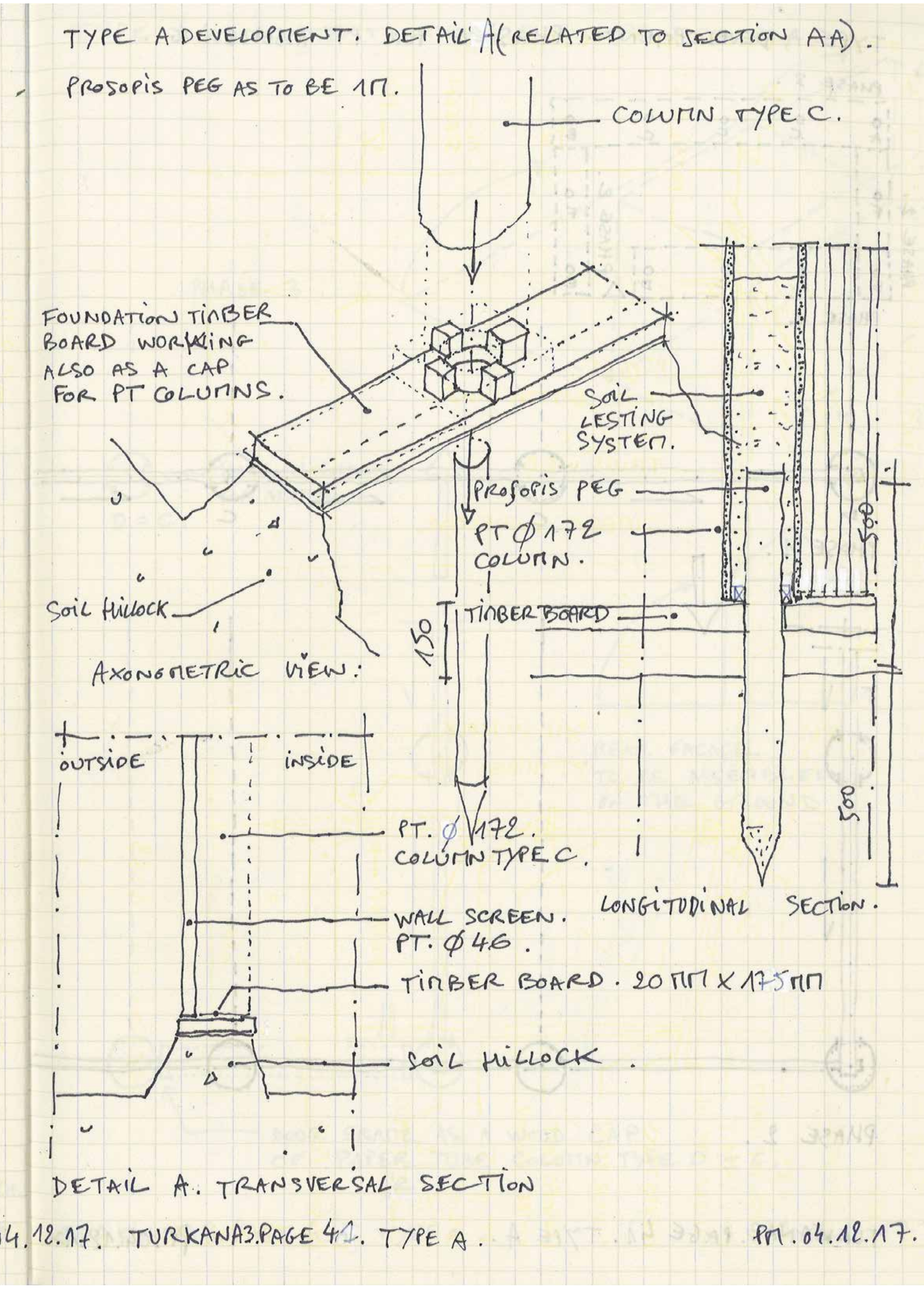
Lessons Learned. Towards On-site Solutions

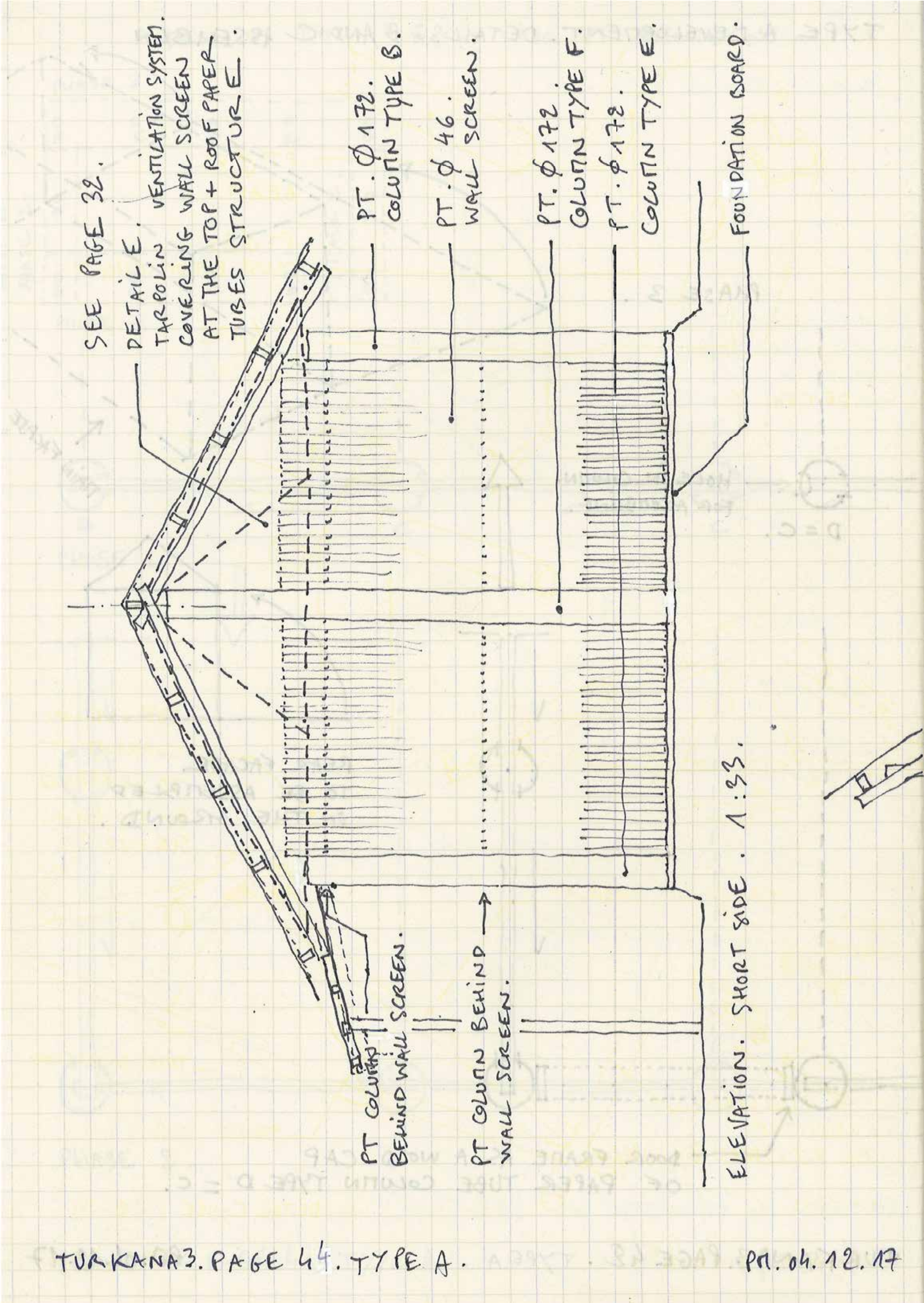
During the preparation process, I realised that some construction details cannot be resolved on paper, and it is easier to address them on site during construction.

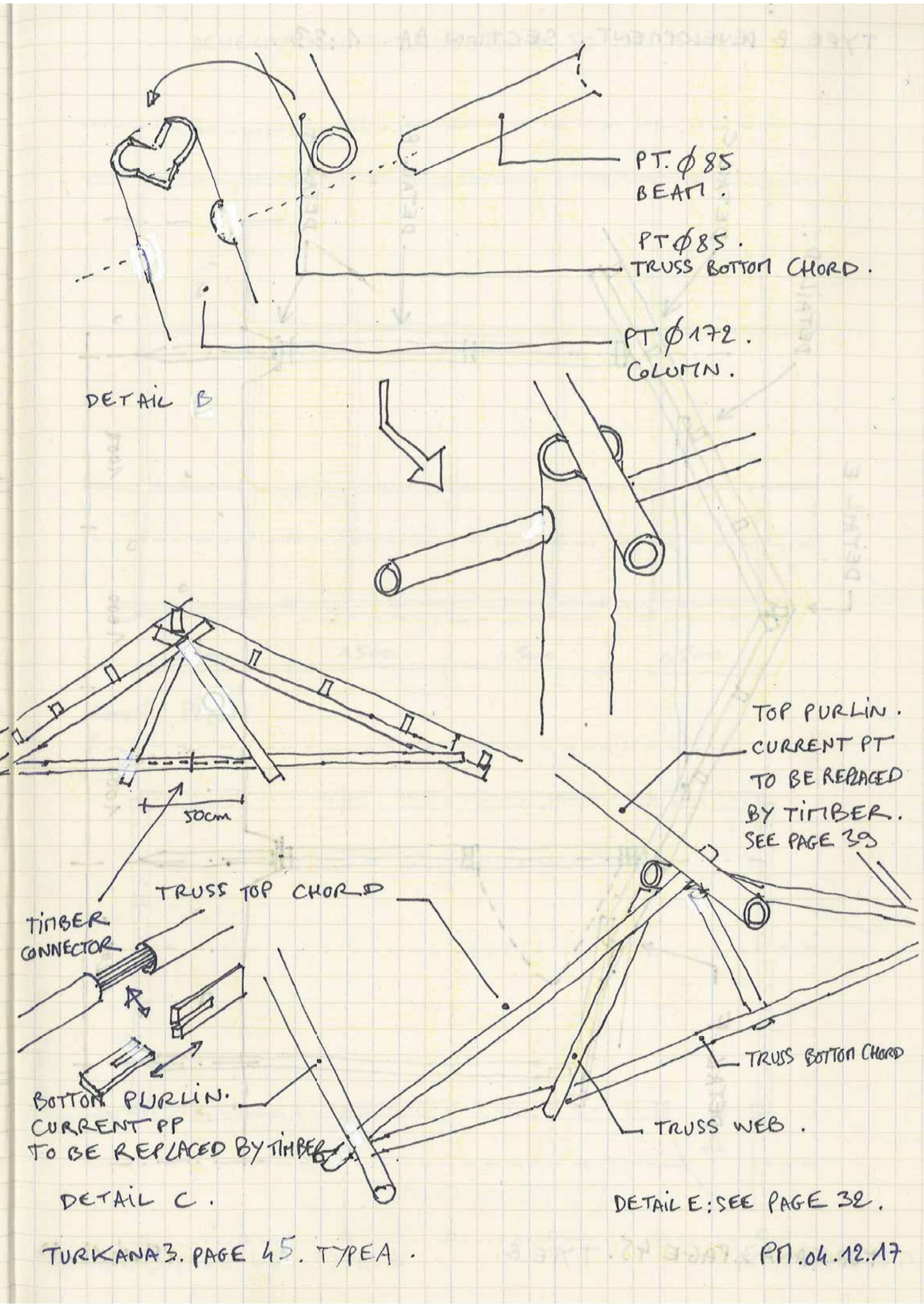
Following pages: extracts from Sketchbook n°3. Principles for shelter construction

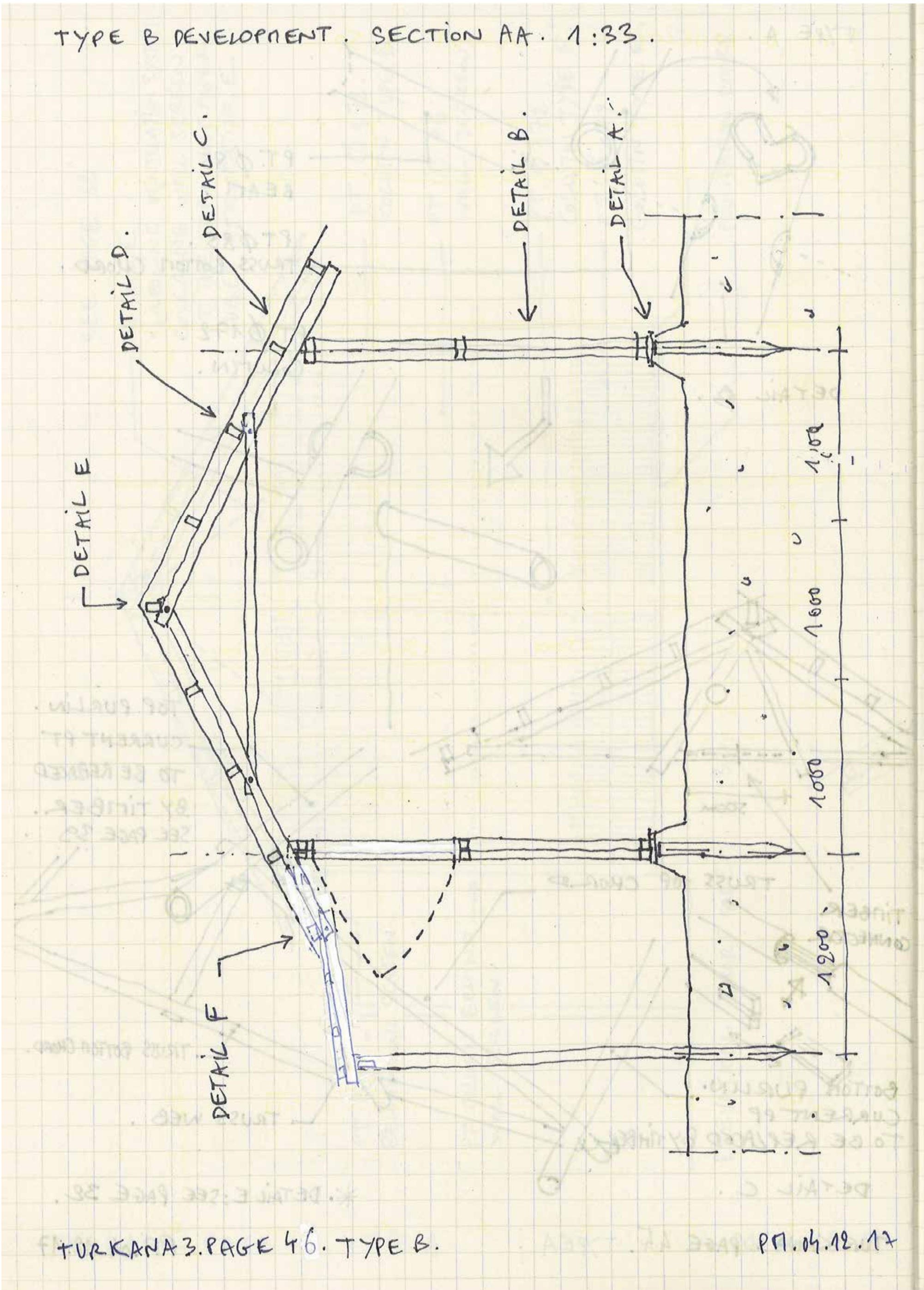

TYPE A DEVELOPMENT.
1500
1500
1500
1500
1500
1500
ROOF PLAN. 1:50
WITHOUT PORCH
1500
375
750
375
1500
750
750
PLAN. 1:50
WITHOUT PORCH.
TURKANA3. PAGE 38. TYPE A.
PM.04.12.17
TYPE A DEVELOPMENT. LAYOUT.
1500
1500
1500
1500
1500
1500
ROOF PLAN. 1:50.
FLOOR PLAN. 1:50.
1500
1500
1500
375
750
375
1500
750
750
TURKANA3. PAGE 39. TYPE A.
PM.04.12.17

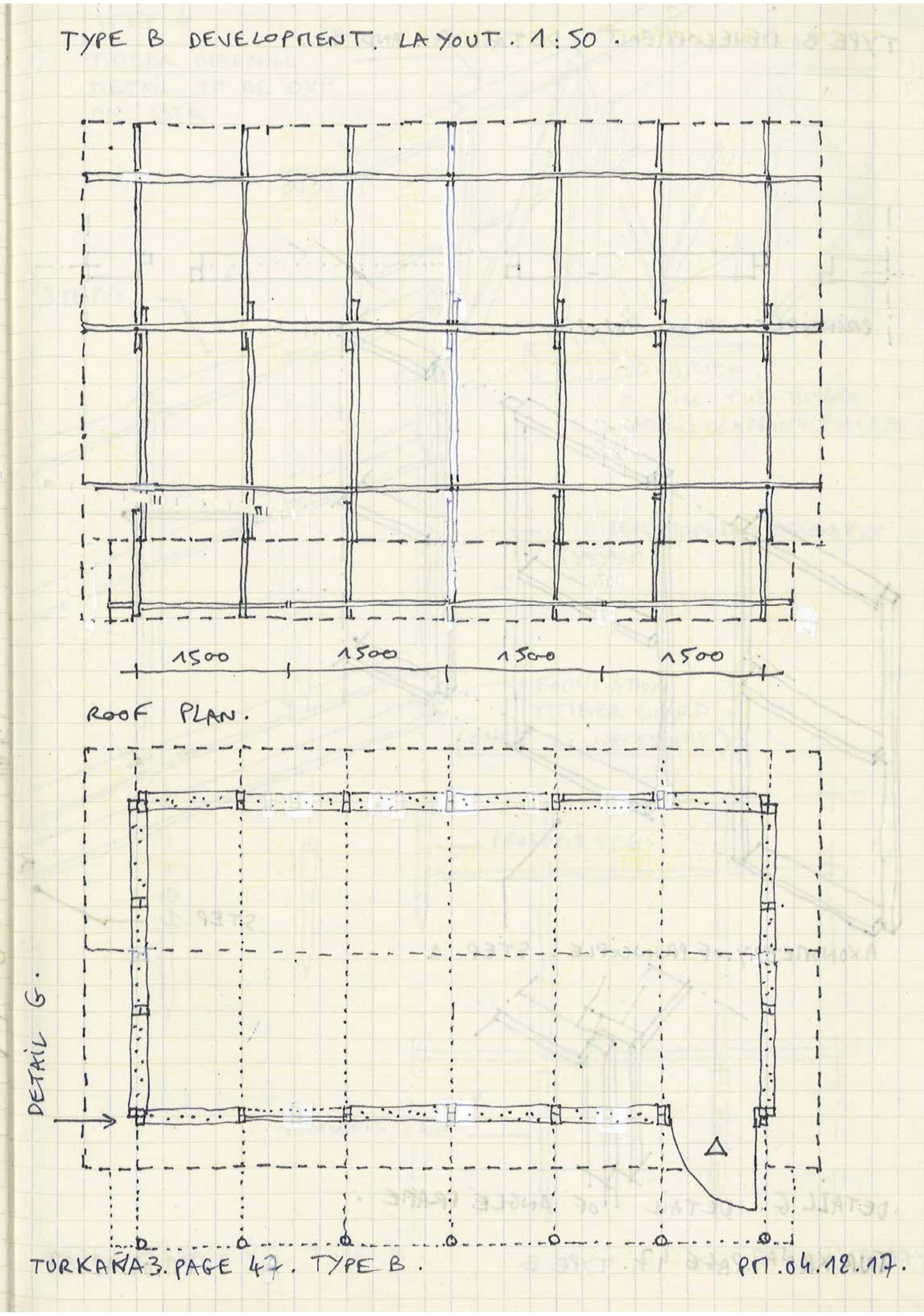

TYPE A DEVELOPMENT. SECTION AA.
+3350
2850
150
DETAIL B
DETAIL C
PT Ø 85.
TRUSS. BOTTOM CHORD.
PT Ø 85.
TRUSS WEB.
TIMBER CONNECTOR
DETAIL D
1500
1500
1800
SOIL HILLOCK
PT TIMBER CAP
DETAIL A
SECTION AA. 1:33
IRON SHEET
TIMBER PURLIN
PLASTIC SHEET
PT Ø 85
TRUSS. TOP CHORD
IRON SHEET
TIMBER PURLIN
PROSOPIS TRUSS
TIMBER BEAM
PROSOPIS POST
TIMBER WINDOW
PT. Ø 85
BEAM.
PT Ø 172
COLUMN TYPE C.
PROSOPIS PEG
TURKANA3.PAGE 40. PM. 04.12.17.

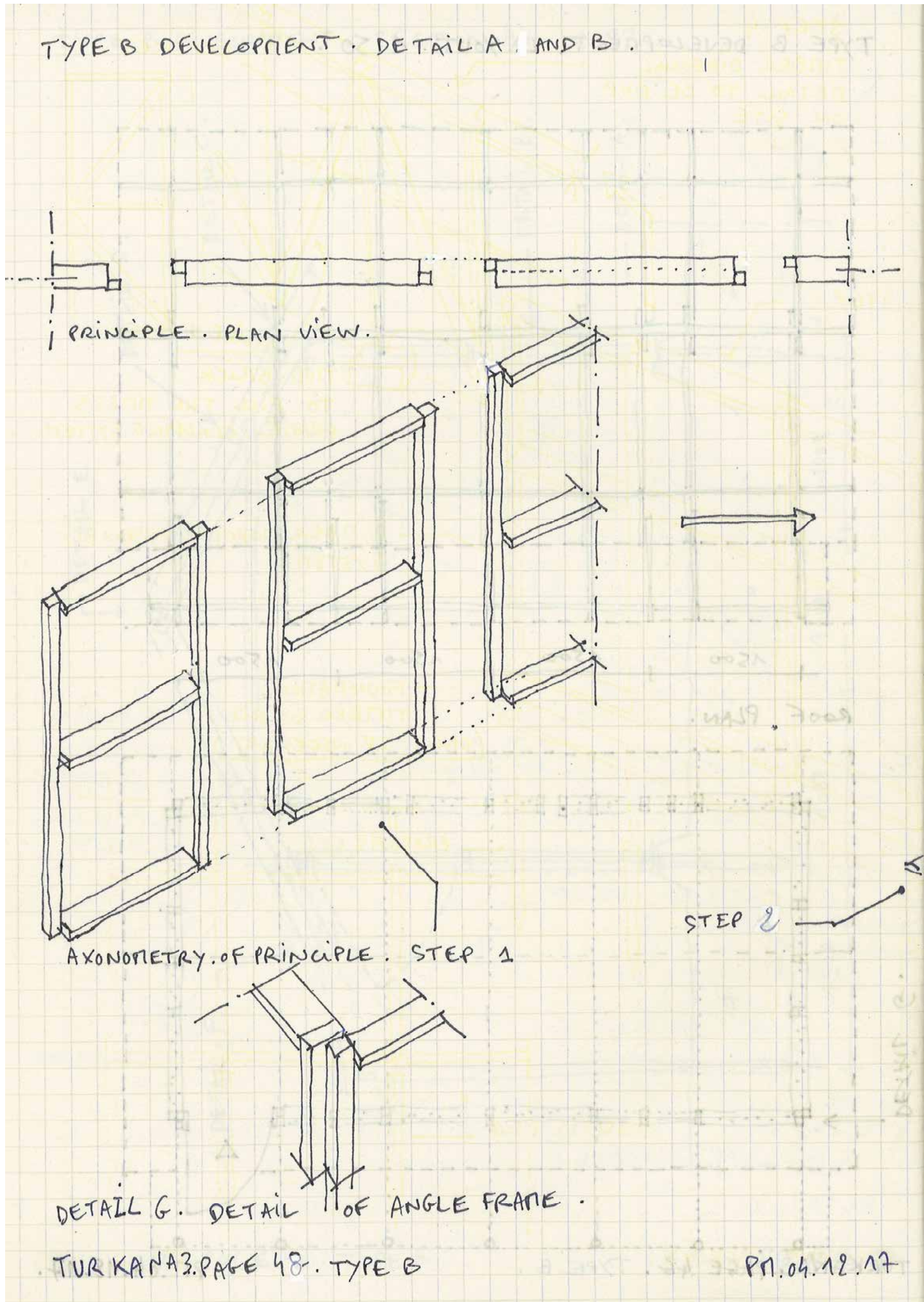

TYPE A DEVELOPMENT. DETAIL A (RELATED TO SECTION AA).
PROSOPIS PEG AS TO BE 1M.
COLUMN TYPE C.
FOUNDATION TIMBER BOARD WORKING ALSO AS A CAP FOR PT COLUMNS.
SOIL LESTING SYSTEM.
PROSOPIS PEG
PT Ø 172 COLUMN.
SOIL HILLOCK
TIMBER BOARD
150
500
500
AXONOMETRIC VIEW:
OUTSIDE
INSIDE
PT. Ø 172.
COLUMN TYPE C.
LONGITUDINAL SECTION.
WALL SCREEN.
PT. Ø 46.
TIMBER BOARD. 20 MM X 175 MM
SOIL HILLOCK.
DETAIL A. TRANSVERSAL SECTION
TURKANA3.PAGE 41. TYPE A.
PM. 04.12.17.

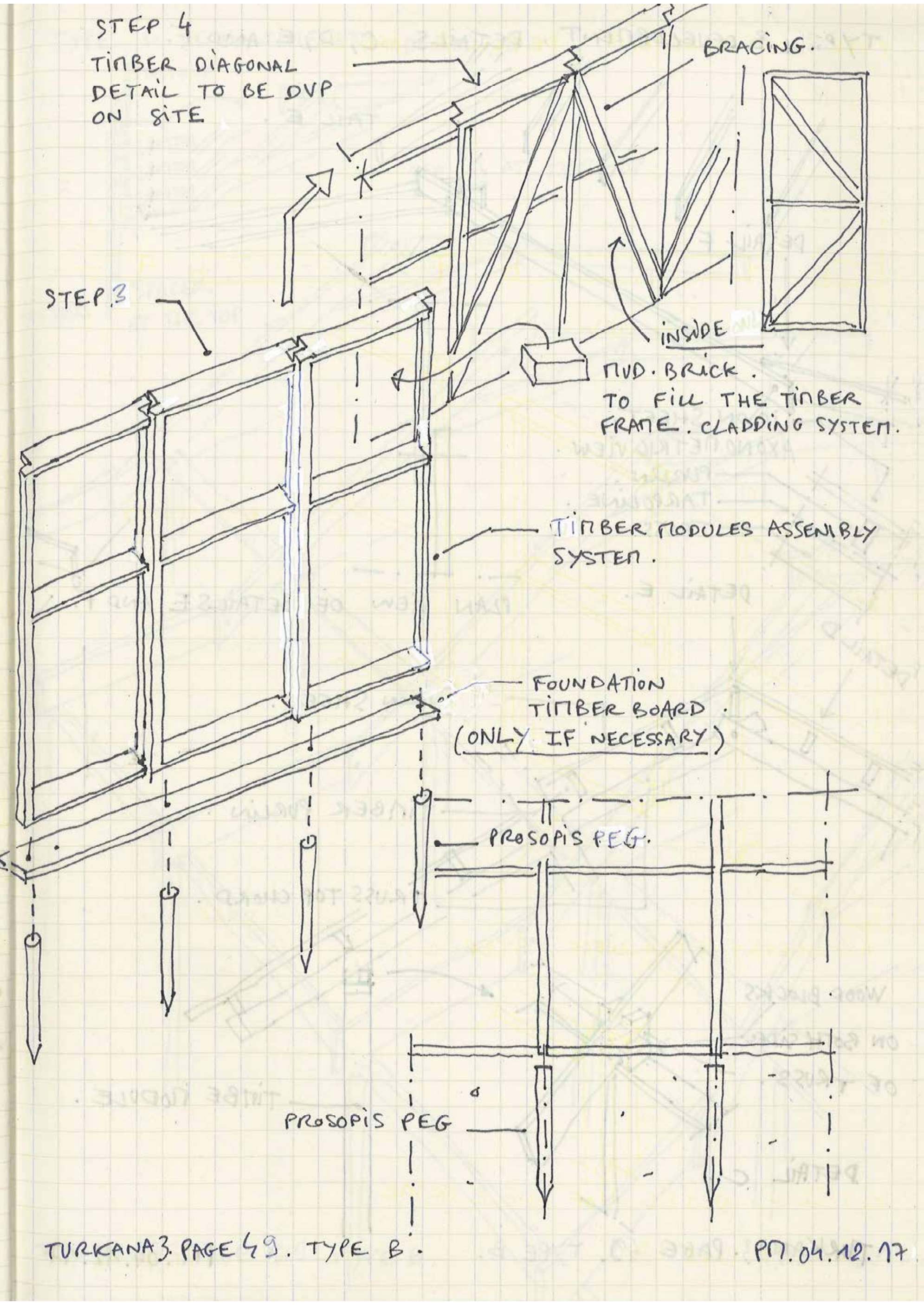

SEE PAGE 32.
DETAIL E.
TARPOLIN VENTILATION SYSTEM.
COVERING WALL SCREEN
AT THE TOP + ROOF PAPER
TUBES STRUCTURE.
PT. Ø 172.
COLUMN TYPE B.
PT. Ø 46.
WALL SCREEN.
PT. Ø 172
COLUMN TYPE F.
PT. Ø 172.
COLUMN TYPE E
FOUNDATION BOARD.
PT COLUMN BEHIND WALL SCREEN.
PT COLUMN BEHIND WALL SCREEN.
ELEVATION. SHORT SIDE. 1:33.
TURKANA3. PAGE 44. TYPE A.
PM. 04.12.17

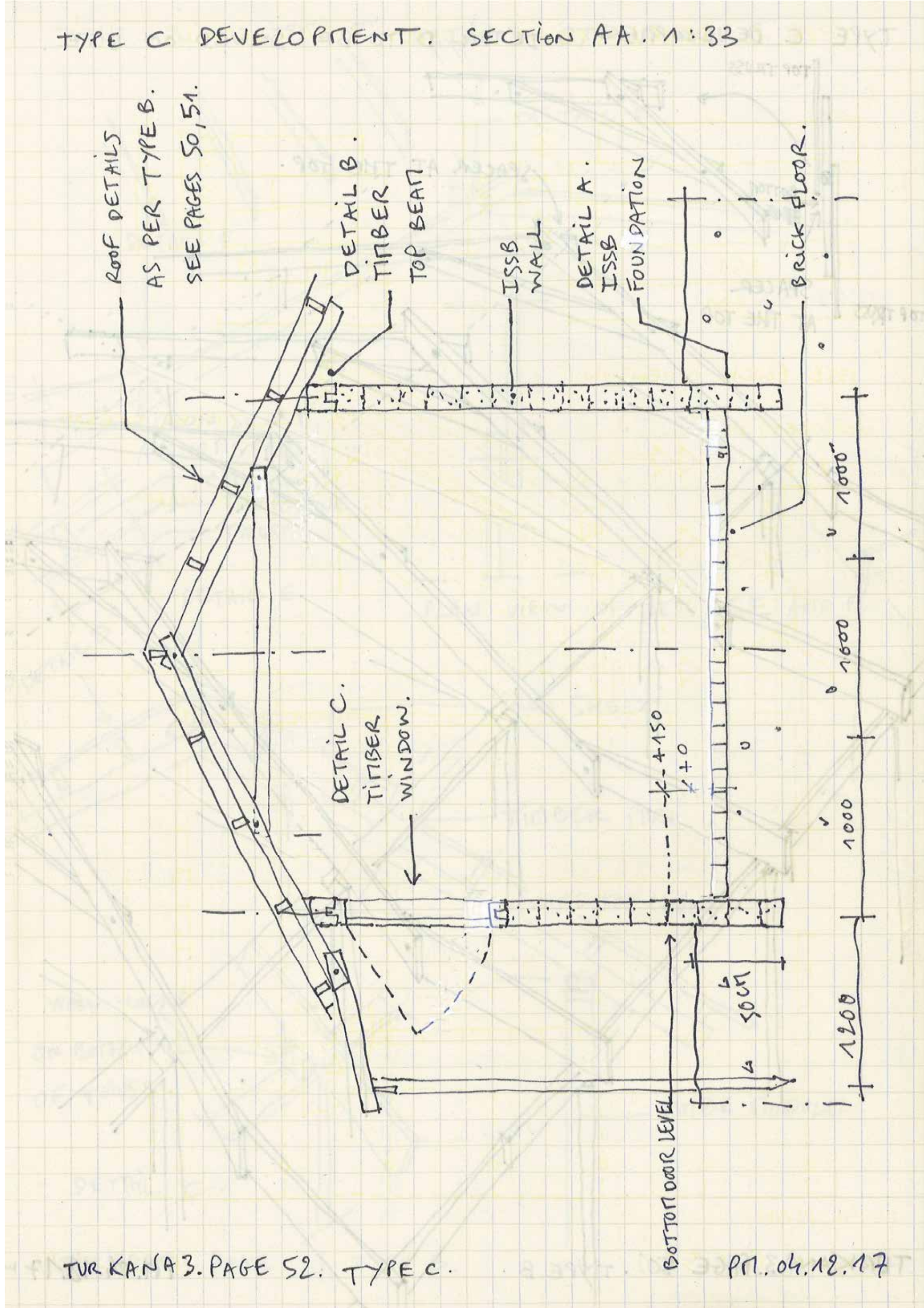

PT. Ø 85
BEAM.
PT Ø 85.
TRUSS BOTTOM CHORD.
PT Ø 172.
COLUMN.
DETAIL B
50cm
TOP PURLIN.
CURRENT PT
TO BE REPLACED
BY TIMBER.
SEE PAGE 39
TRUSS TOP CHORD
TIMBER
CONNECTOR
TRUSS BOTTOM CHORD
TRUSS WEB.
BOTTOM PURLIN.
CURRENT PP
TO BE REPLACED BY TIMBER
DETAIL C.
DETAIL E: SEE PAGE 32.
TURKANA3. PAGE 45. TYPE A.
PM.04.12.17

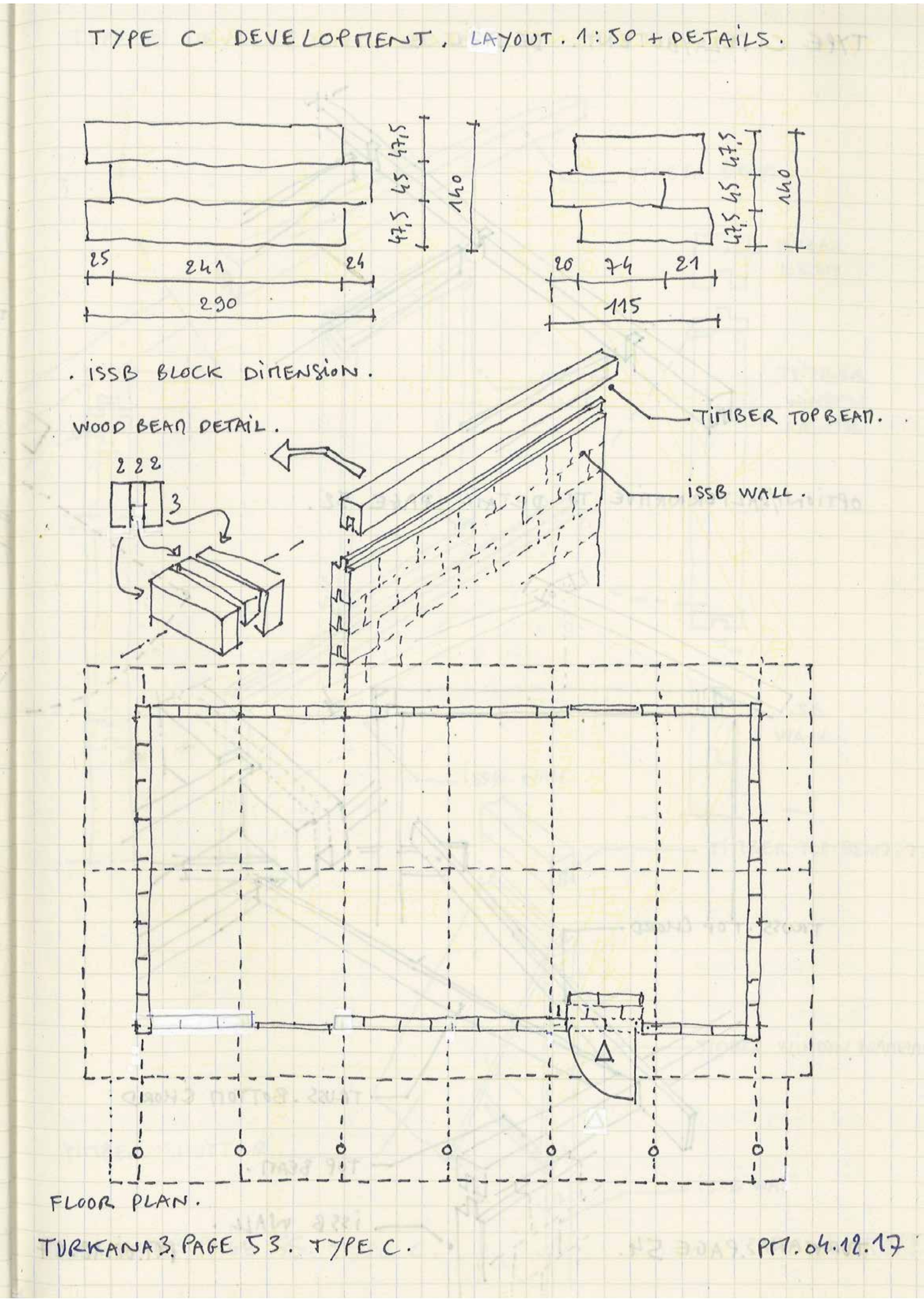

TYPE B DEVELOPMENT. SECTION AA. 1:33.
DETAIL C.
DETAIL B.
DETAIL A.
DETAIL D.
DETAIL E
DETAIL F
1000
1600
1000
1200
TURKANA 3. PAGE 46. TYPE B.
PM. 04.12.17


TYPE B DEVELOPMENT. LAYOUT. 1:50.
1500
1500
1500
1500
ROOF PLAN.
DETAIL G.
TURKANA 3. PAGE 47. TYPE B.
PM. 04.12.17.


TYPE B DEVELOPMENT . DETAIL A . AND B .
PRINCIPLE . PLAN VIEW .
AXONOMETRY . OF PRINCIPLE . STEP 1
STEP 2
DETAIL G . DETAIL OF ANGLE FRAME .
TURKANA3. PAGE 48 . TYPE B
PM. 04.12.17


STEP 4
TIMBER DIAGONAL
DETAIL TO BE DVP
ON SITE
BRACING.
STEP 3
INSIDE
MUD . BRICK .
TO FILL THE TIMBER
FRAME . CLADDING SYSTEM.
TIMBER MODULES ASSEMBLY
SYSTEM .
FOUNDATION
TIMBER BOARD
(ONLY IF NECESSARY)
PROSOPIS PEG.
PROSOPIS PEG
TURKANA3. PAGE 49 . TYPE B .
PM. 04.12.17


TYPE C DEVELOPMENT. SECTION AA. 1:33
ROOF DETAILS AS PER TYPE B. SEE PAGES 50, 51.
DETAIL B. TIMBER TOP BEAM
ISSB WALL
DETAIL A. ISSB FOUNDATION
BRICK FLOOR.
DETAIL C. TIMBER WINDOW.
+150
±0
1000
1600
1000
1200
50cm
BOTTOM DOOR LEVEL
TURKANA 3. PAGE 52. TYPE C.
PM. 04.12.17


TYPE C DEVELOPMENT. LAYOUT. 1:50 + DETAILS.
47,5 45 47,5
140
25
241
24
290
20
74
21
115
. ISSB BLOCK DIMENSION.
WOOD BEAM DETAIL.
2 2 2
3
TIMBER TOP BEAM.
ISSB WALL.
FLOOR PLAN.
TURKANA 3. PAGE 53. TYPE C.
PM. 04.12.17

Building, Revising...

On the Construction Site

Mission M06. End-December 2017

Building the Foundations

December 12th. I am in Kalobeyei Settlement. All the building materials are on site, and construction workers are ready to get started. I meet Gilbert[16], who will become the team leader for the construction of the shelters. Each pilot building has a team dedicated to its construction.
We position the Prosopis poles for the construction of Type A and Type B houses, and I check on the progress of the Type C foundations. Last week, while the ISSBs were being made, Peter and the team started on the foundations. They dug a 50cm trench for the walls, poured a layer of bedding mortar of 15cm to create a flat surface to lay the ISSBs, and laid five rows of blocks, with the last row above ground level.

December 13th. The paper tubes are delivered to UN World Food Programme compound at dawn (Fig. 24). Waiting for their arrival on site, we continue to work on the foundations, nailing the boards to the poles of the Type B House, and making holes in the boards for Type A. I had naively thought that I could use the drill with a hole-saw to create holes in the board, but it does not work as I had hoped. We spend half a day trying to turn on the generator to use the drill, only to find that the drill has burned out because the wood was not dry. After this experience, I realise that I need to adjust the details accordingly to available tools – in this case, manual tools!

Fig. 24. Type A. A delivery of paper tubes in World Food Programme compound, in Kakuma

Fig. 25 Type A. Trial assembly of paper tubes

Fig. 26. Type A. Foundation boards interlocked and nailed to the poles. Gilbert in action

Type A. Fun with Paper Tubes…and Issues

In the evening after the failure with the drill, we are still hoping to see some progress. I decide to assemble the paper tubes beside the foundations. It is a very exciting moment, and many people from nearby come to observe. Some even help, curious about the paper structure (Fig. 25). I feel like we are bringing something remarkable to Kalobeyei, and perhaps this is helping to create some hope and curiosity amongst residents.

December 14th. We change the technique of drilling holes to creating cuts in the corners with a manual saw (Fig. 26). From now on, we will do all construction without the use of electricity. This is good, but we face a very interesting challenge: how to build using minimal tools and skills.

After placing the foundation boards through the poles, we manage to slot the paper tubes into them. The structure is surprisingly light. Some refugees begin to question its structural integrity.

In the evening, Catherine from the UN-Habitat Kakuma office arrives. We try to weave few thin paper tubes together. As soon as we start, we observe three things:
1. It is difficult to align the tubes straight during the assembly process
2. A tiny space is created between tubes due to their thickness
3. The design lacks a skirting panel, which will be essential to tighten the tubes at the bottom. We have to create a wooden one.

December 15th. Catherine Huot, 'our Turkana architect' is here to work on the cladding with two other Turkana women from Kalobeyei Town. It turns out that it is very quick and easy to assemble the structure. It is, however, much more challenging to ensure the cladding looks aesthetically pleasing. At least everybody looks happy to participate - the innovative construction creates positive energy (Fig. 27, 28, and 29).
The paper tube cladding will be completed in the evening, but I am not happy with the result. The structure, cladding and the entire shelter is leaning to one side.

Type B. 'The Big Furniture'

While the Paper Tube House is under construction, another team is working on the Timber Frame House (Type B).

December 12th. We test the assembly detail. An interesting thing happens when we position the timber frames of Type B on the foundations without nailing them. In

Fig. 27. Type A. Paper tube cladding with rope. Turkana architects

Fig. 28. Type A. Paper tube cladding with rope. General view

Fig. 29. Type A. Paper tube cladding with rope. Catherine weaving tubes with twine

a very short time, we can visualise how the cladding can be constructed in steps, akin to assembling furniture. This process looks very efficient, and will be a good opportunity for a carpentry business in Kalobeyei Town (Fig. 30).

December 13th. The foundations boards are nailed to the poles (Fig. 31).
Next, the timber frames are nailed on the foundation boards. Within two hours, the walls have been erected. Though many people are willing to help assemble the paper tube structure, only three people help with the wooden frame of the Type B House. The construction of the latter seems more arduous, but is just as quick as the assembly of the Paper Tube House. Meanwhile, the Type B team is already starting to build the roof trusses.

December 15th. The entire structure except for the bracing is completed (Fig. 32). One of the main challenges is keeping the timber frames straight. It is difficult to get straight pieces of wood in Turkana, because there are few machines available which can make accurate cuts. Unfortunately, this means our construction time is extended. The structure is designed to be constructed like flat-pack furniture, with pre-fabricated pieces assembled on site. However, we discover the limitations of this approach during the construction process. If we can support the host

Fig. 30. Type B. Testing the assembly of timber frames

Fig. 31. Type B. Nailing boards onto the poles

Fig. 32. Type B. Completion of the timber structure. Bruno is on the roof.

community to set up a cooperative organisation to produce quality timber frames, what was once an issue could become a positive enterprise for the community.

Type C. A Lego Experience

Like the Type B team, the builders for Type C are working tirelessly in the background while crowds flock to the structure with the paper tubes. Block by block, they build the walls of the house (Fig. 33).

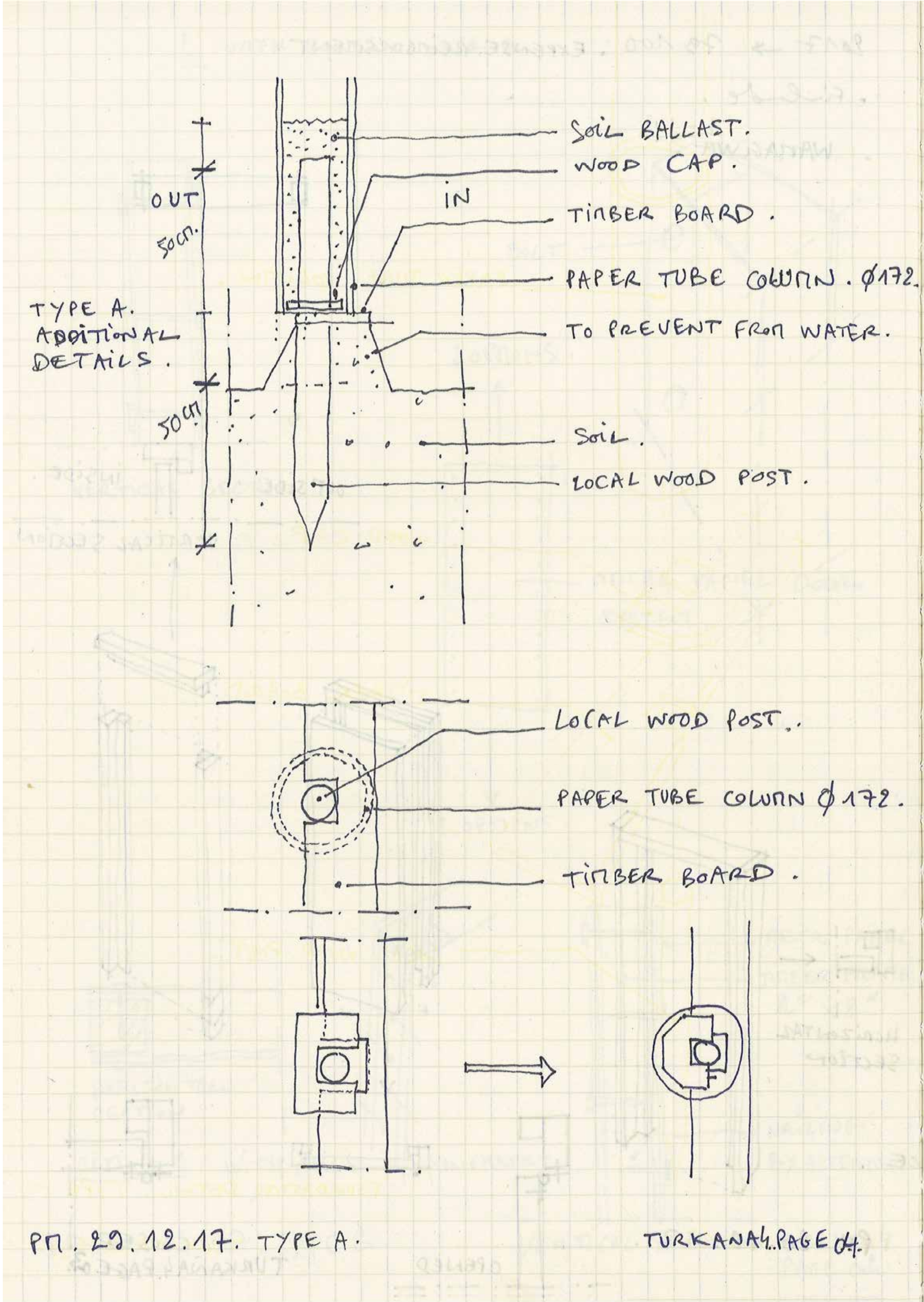
December 15th. Before leaving the site, I work with Gilbert to realise the detail for the door and window frame interlocked with blocks, which I created on the 4th of December.

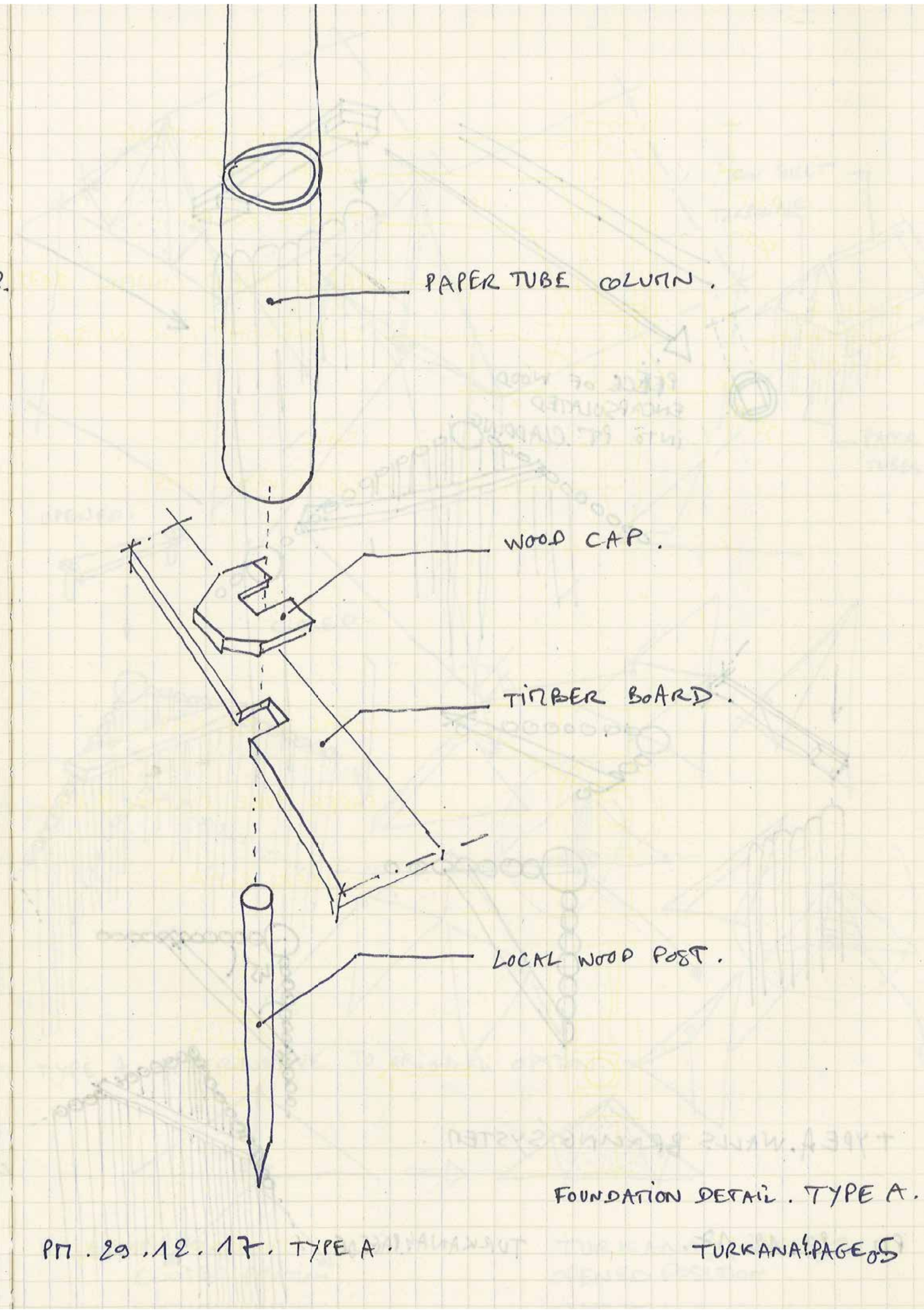
Fig. 33. Type C. The cladding process, with CEBs

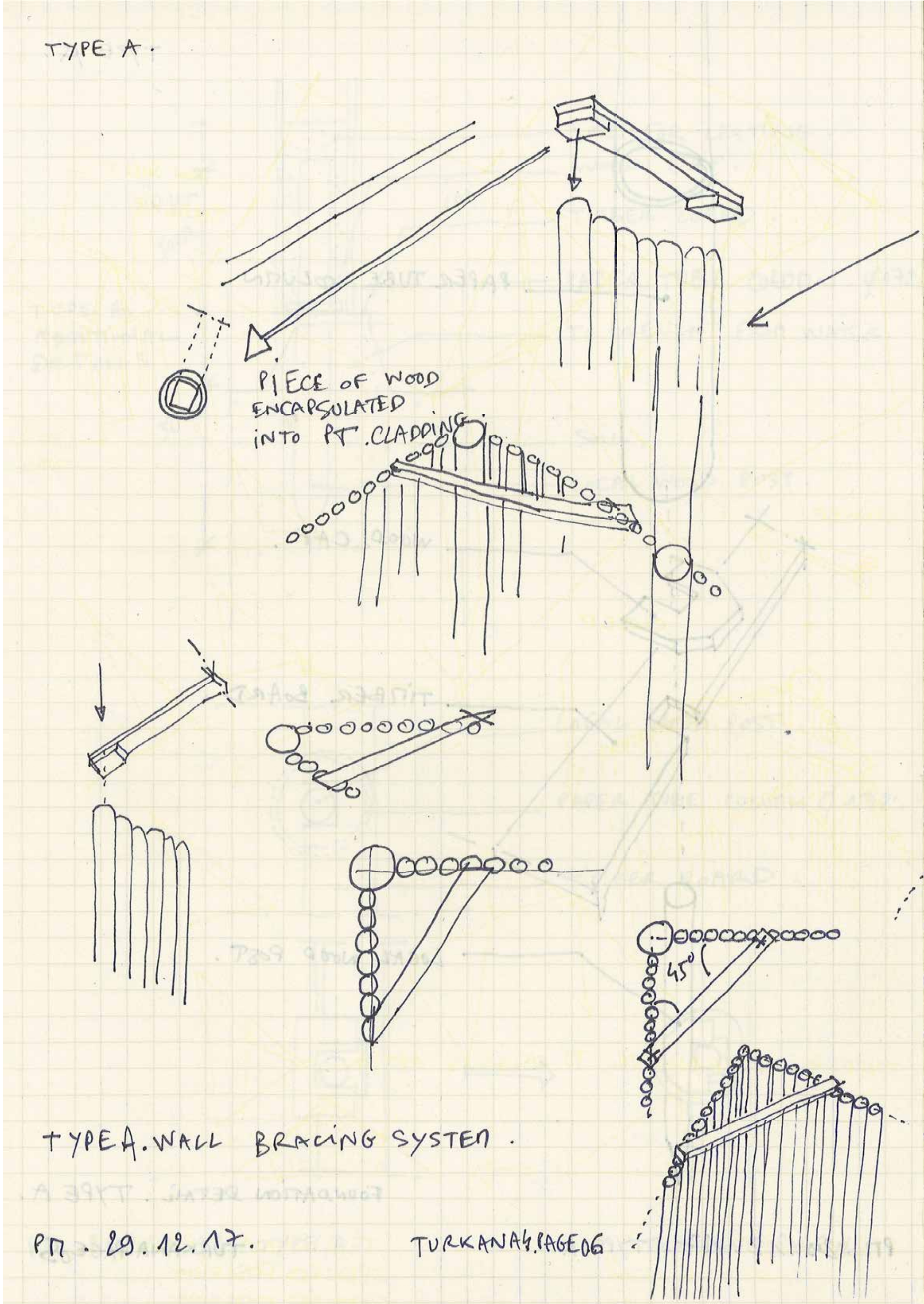
Building with ISSBs presents two significant challenges: it is difficult to build a straight wall, and the work must be very precise. While we are stacking the blocks, we discover that the foundations are not forming a perfect rectangle, but a shape more like a lozenge. We correct it by creating some spaces between the blocks on one side.
We will understand later that it is not good option for the stability of the structure. I now understand that CEB walls must be constructed by a skilled bricklayer.

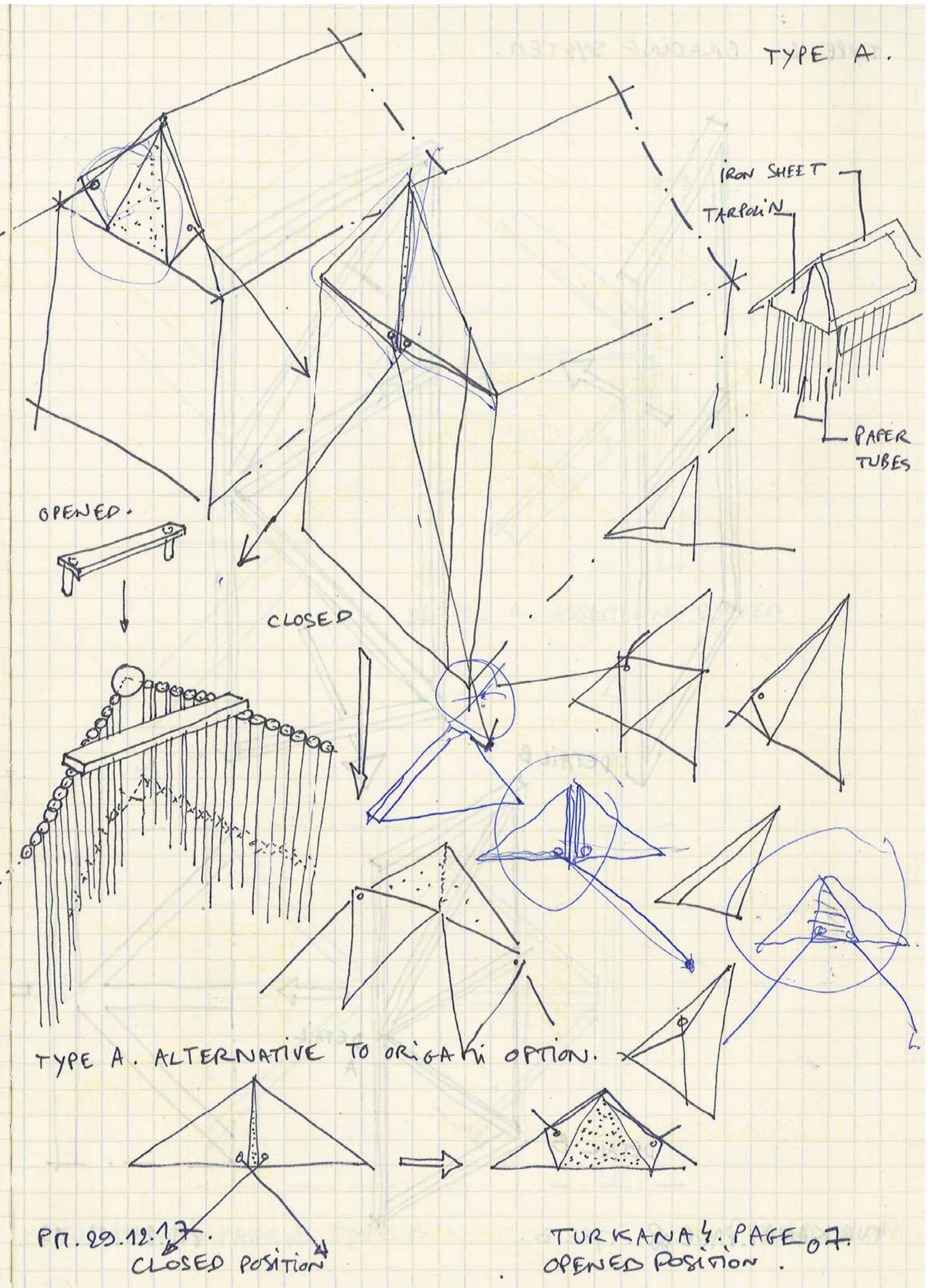
Lessons Learned. Lack of Skills on the Ground
During this first construction mission, the team faced many trials. Each shelter type had its own challenges: cladding details for the Type A House had to be reviewed, timber procured for Type B was of poor quality, and Type C required greater construction precision. However, the main challenge was the lack of skills on the ground. When we started the cladding for the Type A House, many people wanted to help. This made it difficult to supervise construction, which impacted the results for both the Type A and Type C houses. The team and their non-skilled helpers had thought it would be easy, like playing with Lego bricks. They stacked blocks without checking the vertical alignment, and the finished walls had a lean which meant they were not structurally sound. This experience taught me that we needed smaller construction teams – just a couple of skilled people. I would also have to train this team to build every pilot typology. Though building teams usually consist of an architect, an engineer and a contractor, I realise that I might have to play all these roles. In addition, every detail would need to be redrawn, to account for material quality, lack of tools and climatic conditions, all of which would shape future iterations of the three pilots. Research and designing on paper was a very small step in the process.

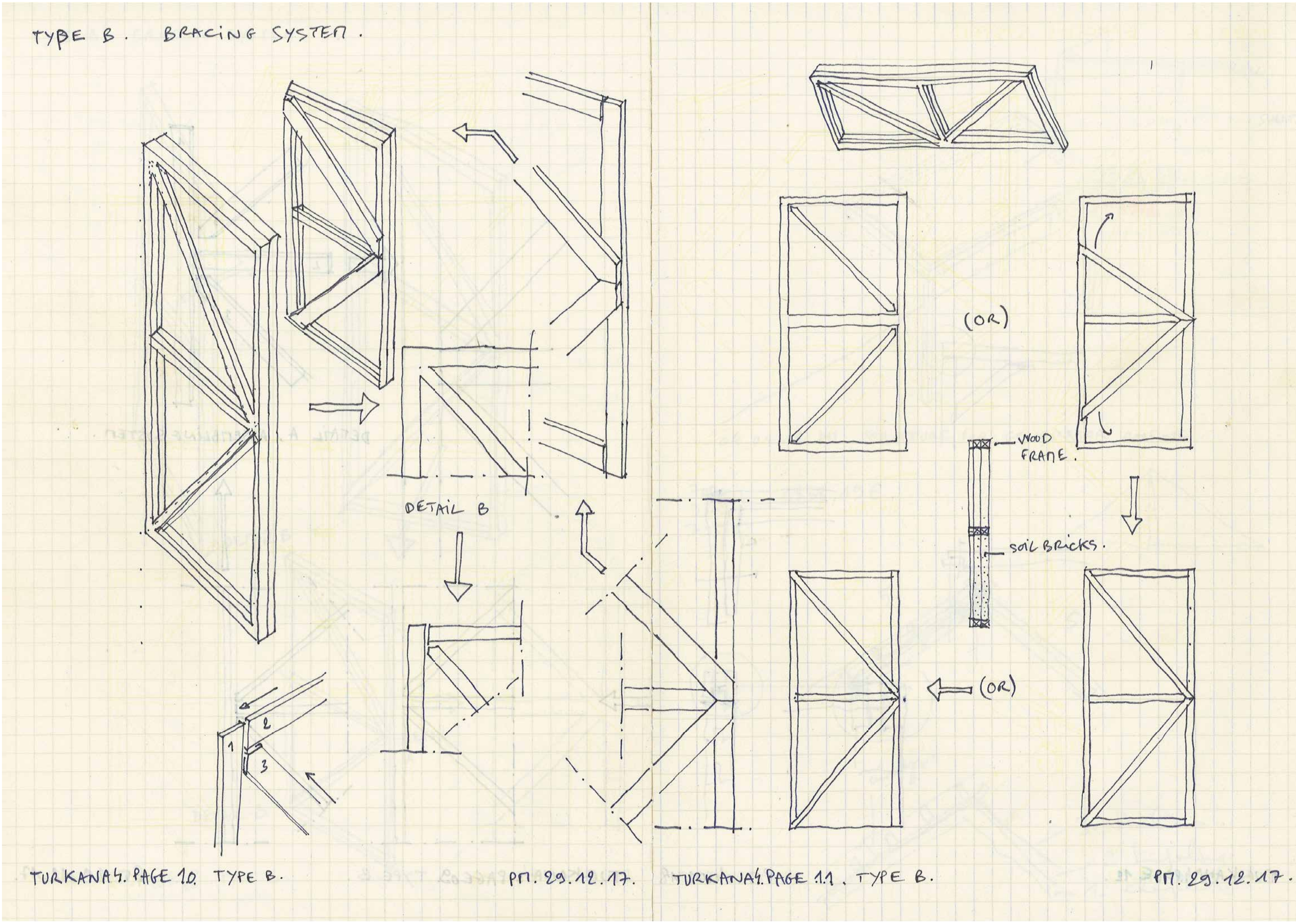
Following pages: extracts from Sketchbook n°4. Detail research for Types A + B


SOIL BALLAST.
WOOD CAP.
OUT
IN
50cm.
TIMBER BOARD.
PAPER TUBE COLUMN. Ø172.
TYPE A.
ADDITIONAL
DETAILS.
TO PREVENT FROM WATER.
50cm
SOIL.
LOCAL WOOD POST.
LOCAL WOOD POST.
PAPER TUBE COLUMN Ø172.
TIMBER BOARD.
PM. 29.12.17. TYPE A.
TURKANA4.PAGE 04.


PAPER TUBE COLUMN.
WOOD CAP.
TIMBER BOARD.
LOCAL WOOD POST.
FOUNDATION DETAIL. TYPE A.
PM. 29.12.17. TYPE A.
TURKANA4.PAGE 05


TYPE A.
PIECE OF WOOD
ENCAPSULATED
INTO PT. CLADDING
45°
TYPE A. WALL BRACING SYSTEM.
PП. 29.12.17.
TURKANA4.PAGE06


TYPE A.
IRON SHEET
TARPOLIN
PAPER
TUBES
OPENED.
CLOSED
TYPE A. ALTERNATIVE TO ORIGAMI OPTION.
PП. 29.12.17.
CLOSED POSITION
TURKANA4. PAGE 07
OPENED POSITION.


TYPE B. BRACING SYSTEM.
DETAIL B
1
2
3
TURKANA4. PAGE 10. TYPE B.
PM. 29.12.17.
(OR)
WOOD FRAME.
SOIL BRICKS.
(OR)
TURKANA4. PAGE 11. TYPE B.
PM. 29.12.17.

Repairs and Discoveries

Mission M07. Janunary 2018

Back in Nairobi, I sketch some ideas to improve the construction details for the three houses. Shigeru Ban suggests that I add corner bracings to stabilize the paper tube walls. I consider using tarpaulin sheets for ventilation on the short façades of the house. With Shigeru Ban's agreement, I decide to buy some fine galvanized wire in Nairobi to replace the rope. This can be used to join the tubes together and drastically reduce the space between them, and is likely to last for many years, making it a more durable solution.

Quality Versus Quantity

January 8th. I return to the site to see how construction is progressing, and find it is inadequate and will need to be redone.
Type A: The cladding with rope is not working. There are visible gaps between tubes and the cladding is leaning.
Type B: Some boards had been carelessly nailed to the wood frames, and the metal sheeting for the windows is poorly cut.
Type C: The shelter has been completed, but the wood ring beam has been made with a twisted section of wood. As a result, the walls are structurally unsound and the construction is not safe for use. This pilot will need to be dismantled and entirely rebuilt.

Fig. 34. Type A. Original design (bottom) versus design on site (top)

Fig. 35. Type A. Fabrication of trusses

I decide to drastically reduce the size of the team, to ensure construction is completed to a higher quality. Progress will be slower but supervision will be much easier, hopefully resulting in fewer errors. We are not aiming for mass production of a vast number of houses. We are simply trying to build inexpensive well-built pilot shelters with good construction details. Based on their prior experience, Gilbert and Sedar[17] are selected as team leaders.

Type A. Restarting the Cladding and the Trusses

January 9th. We dismantle the cladding tubes and create channels at the top of the columns for placement of the trusses. The former idea of placing boards at the corners of the house does not work. The house still leans to one side. We decide to use some ropes to temporarily stabilise the structure, as we would for a tent.

January 10th. Gilbert and I start to assemble the trusses. First, we try the developed detail. As I anticipated during my research, we realise it will be too challenging to attach all tubes together at the ridge of the structure. We decide to simplify the system with a central kingpost instead of a triangular one (Fig. 34). After discussion, we also agree that it will be easier to create a nailed connection with pieces of wood

Fig. 36. Type A. A truss ready to be installed on the main structure

on the edges of the tubes, rather than a woven connection (Fig. 35). At the end of the day, all the trusses are complete and we install them on the columns (Fig. 36). Then we encounter a new challenge: the linkage of trusses to the top purlin does not work. As we did with the wall structure, with the help of a few people we easily place the roof structure on the columns. However, the precision of the construction is not good.

January 11th. We remove the entire roof structure and attach only the trusses to the walls, ensuring their exact positions correspond to the columns before adjusting the top purlin to give equal spaces between the trusses. Three of us work together for this construction phase (Fig. 37 and 38).

January 12th. We install the purlins onto the top chords. We previously added some pieces of wood at the extremities of the trusses to nail the top and the bottom purlin. The intermediate ones are banded with wire to the trusses. A nail is used to block the purlin to its position on the top truss (Fig. 39).

January 13th. We decide to position the origami tarpaulin system at the short façades

Fig. 37. Type A. Completion of the trusses and the skirting

Fig. 38. Type A. Trusses attached to the column with bent wire

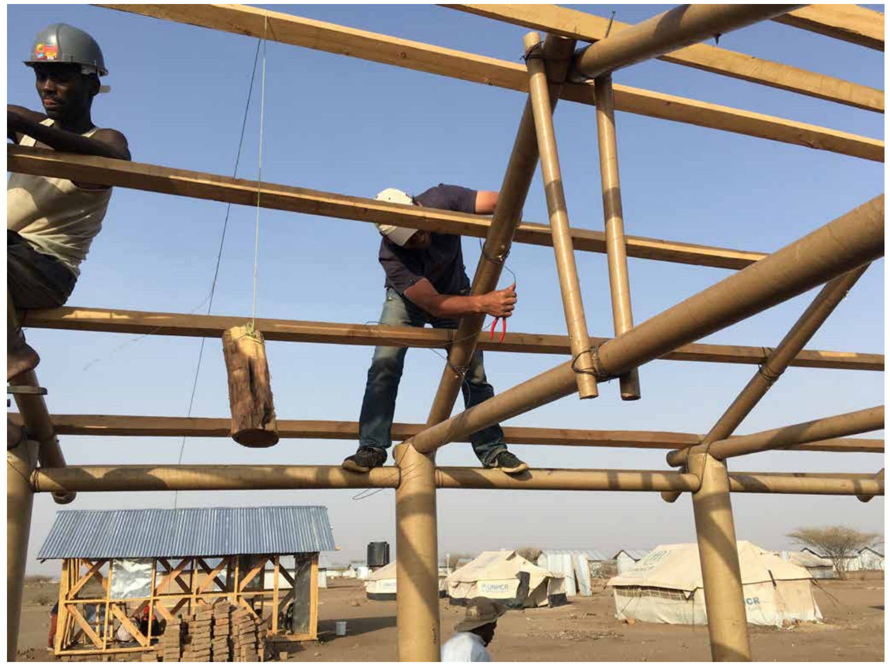


Fig. 39. Type A. Assembly of the purlins

Fig. 40. Type A. Origami system with tarpaulin (with analytical drawing overlaid on the photograph)

of the house. A few weeks ago, I was testing the detail on my kitchen table, cutting and folding a piece of paper. That was easy. Now, we have about 8m² of tarpaulin to install on the top trusses, while being blown by strong wind. That makes our work quite adventurous!
Because we cannot achieve any shaping or sewing on site, we use the rectangular piece of tarpaulin as it is, and try to fold it after its attachment to the top trusses. Finally, after many tests, we manage to sort out a simple folding system, using a similar principle to Shigeru Ban's Kobe houses, except that we do not change the tarpaulin. This experience is encouraging. The lack of tools forces us to find the easiest way to implement the detail. We will repeat this operation on the timber frame house, using the same system and the same material (Fig. 40).

January 14th. Gilbert and I install the insulation system, positioning the tarpaulin around the purlins, and fastening it with nails on the side. It would have been easier to put it under the purlins, but we would have to attach the purlins to the trusses with wire and I don't want to make any holes in the tarpaulin (Fig. 41).
Catherine Arot works with another Turkana woman to redo the cladding of the

Fig. 41. Type A. Tarpaulin on the purlins for insulation

house with the thin wire that I brought from Nairobi. The tubes are relatively straight and the result is very good, but there is still a small space between the tubes due to the thickness of the wire or the lack of straightness of the tubes. It is difficult to tell what is causing the spaces (Fig. 42).

January 15th. Gilbert and Catherine from UN-Habitat install the iron sheets on top of the purlins. Sedar and I work on the cladding. It is a long process but not a very complicated one. More and more people are arriving to observe the construction. At the end of the day, many want to help. Half of the house is covered. All the cladding without the doors and the windows will be completed two days later.

January 18th. As we need to cut the long tubes to create the opening for the windows, I suggest we reuse the materials to create "invisible" windows and doors, on the principle of a hiden door[18]. The first window is completed. The technique is like the main cladding - some tubes are assembled and woven together with the thin wire to a light wood framing. The effect is as expected – only the window sill is visible. The team is happy (Fig. 43).

Fig. 42. Type A. Catherine weaving paper tubes with fine wire

Fig. 43. Type A. The 'invisible window'

Fig. 44. Type B. Bracing

Fig. 45. Type B. Windows: folding aluminium sheet around the timber structure

Type B. Repairs and Progress

January 9th. While Gilbert and I start to work on the Paper Tube House, Sedar and his team replace the bracing of the Timber Frame House. In 3 days, the work is completed (Fig. 44).

January 10th. Catherine from UN-Habitat suggests using the mud bricks under the foundation boards as a water barrier. Following her advice, I think of creating a pattern on all the surface of the house with burnt bricks. I position the mud bricks as a template. Finally, we give up the idea because of the cost. We still put two rows of mud bricks under the foundation boards of the house in a staggered pattern to create a barrier against flash floods.

After the bracing, Sedar and Bruno[19] spend the rest of the duration working on the windows' repairs. As we do not have a way to cut the metal sheets properly, I suggest folding them around the wood structure and nailing them on the side to achieve a sharp edge on the front of the window construction (Fig. 45).

Fig. 46. Type B. Burnt bricks from Kakuma Camp


Fig. 47. *Nyaluak Choul and her painting, Village 4, Kakuma Camp*

January 19th. We trial the filling of the wood frames with some burnt bricks from Kakuma Camp (Fig. 46). Bruno and Omari[20] sift the sand and prepare the mortar, consisting of cement, water and sand, while Gilbert mounts the first bricks inside the timber frame.

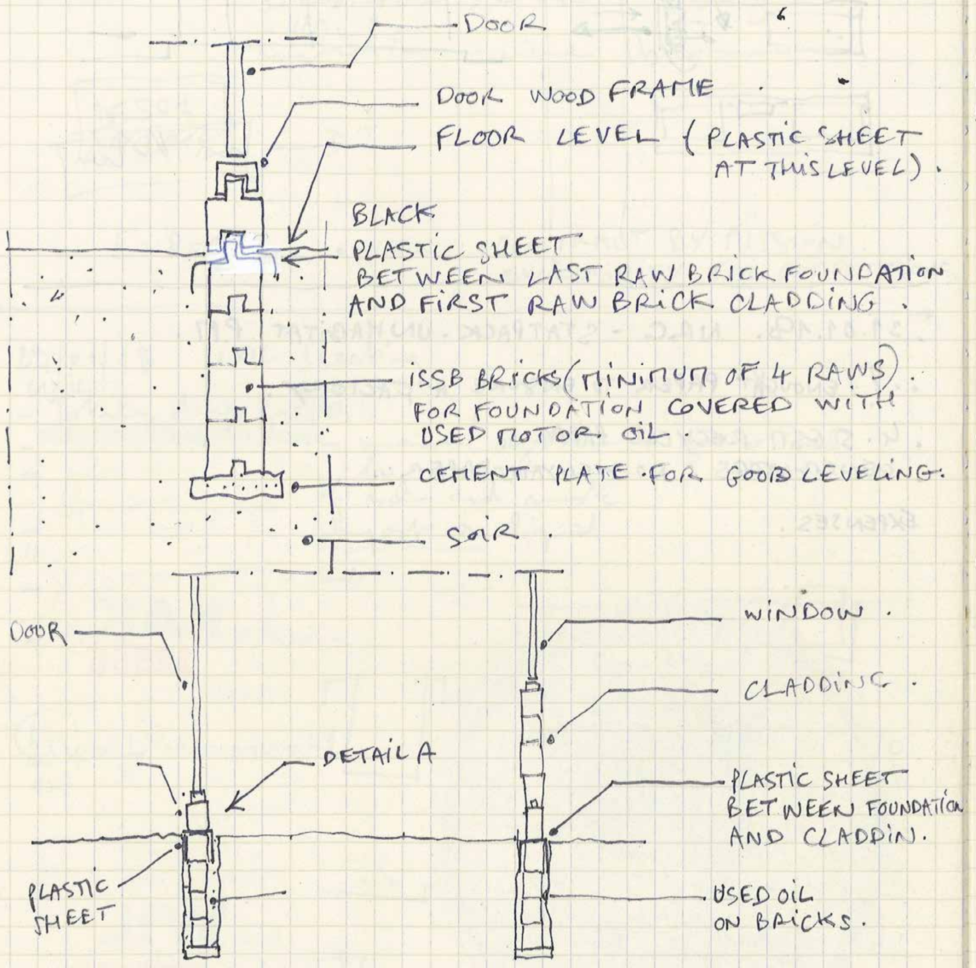
Lessons Learned. Details Evolve Based on Local Conditions

After spending more than a week on site, we have only worked on two pilots. We spent most of our time fixing mistakes from the former mission. With a smaller team we managed to improve a lot of details: invisible windows for the Paper Tube House, strong bracing and folded metal sheet windows for the Wood Frame House, etc. However, the origami system for the sandstorms is probably the most interesting experience of the mission, raising questions about how to find a solution with minimal resources. With available resources, and willpower, there is always a solution.
On the 17th of January, while crossing Kakuma Camp 4 on our way to the site, I see a beautiful painting on the wall of a house. I ask Lucas Ewoi, the driver of UN-Habitat Kakuma, to stop the car, and just by chance I meet the South Sudanese woman who painted it. This artistic intervention is a great way to communicate her culture and to share her thoughts with her neighbours. I see it as a message of hope. It is an expression of her cultural identity[21] (Fig. 47).

Later, she will participate in the construction of our pilot houses. It is a testimony of our lessons learned from Mission M04.

Following pages: extracts from Sketchbook n°4. Details for Type C reconstruction

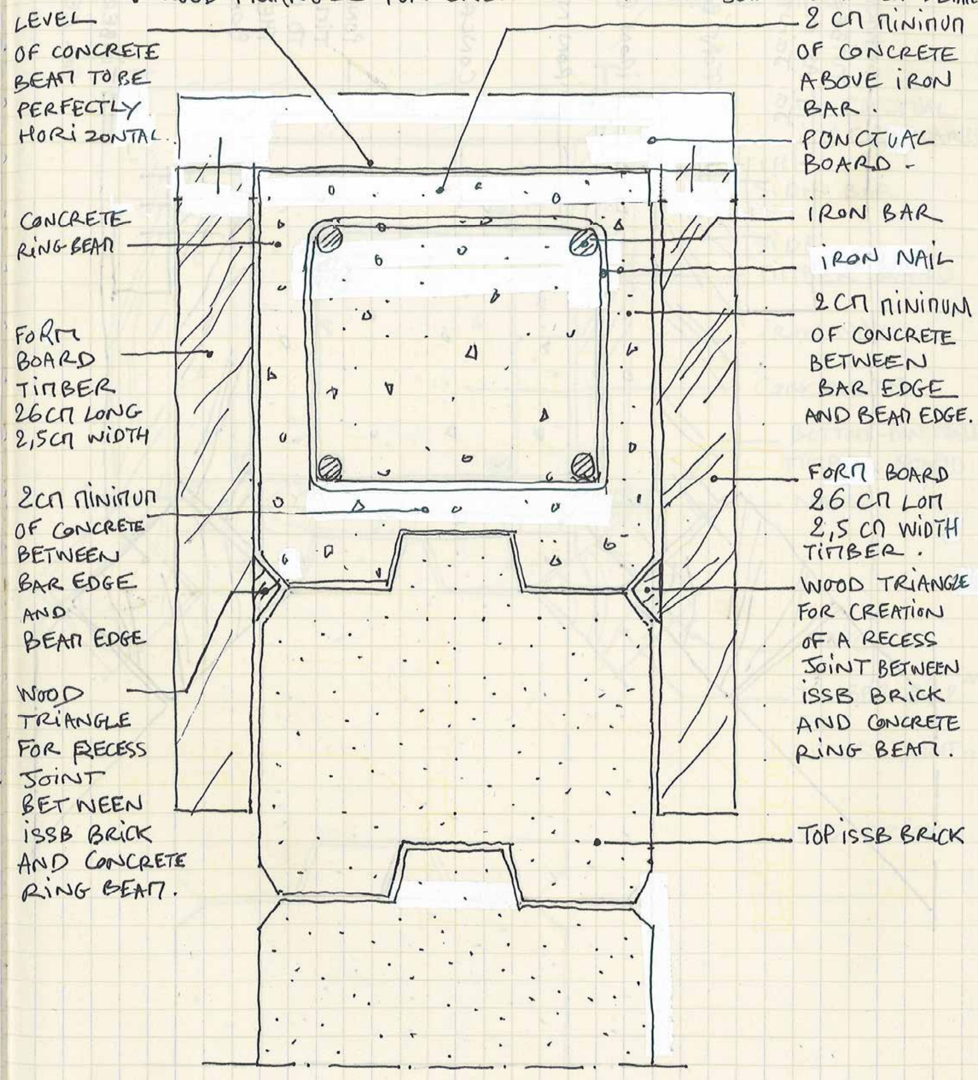
TYPE C. FOUNDATION DETAIL.



TURKANA 4. PAGE 16. TYPE C. PM. 29.01.18

TYPE C. RING BEAM DETAIL. SCALE. 1/2. OPTION 01.

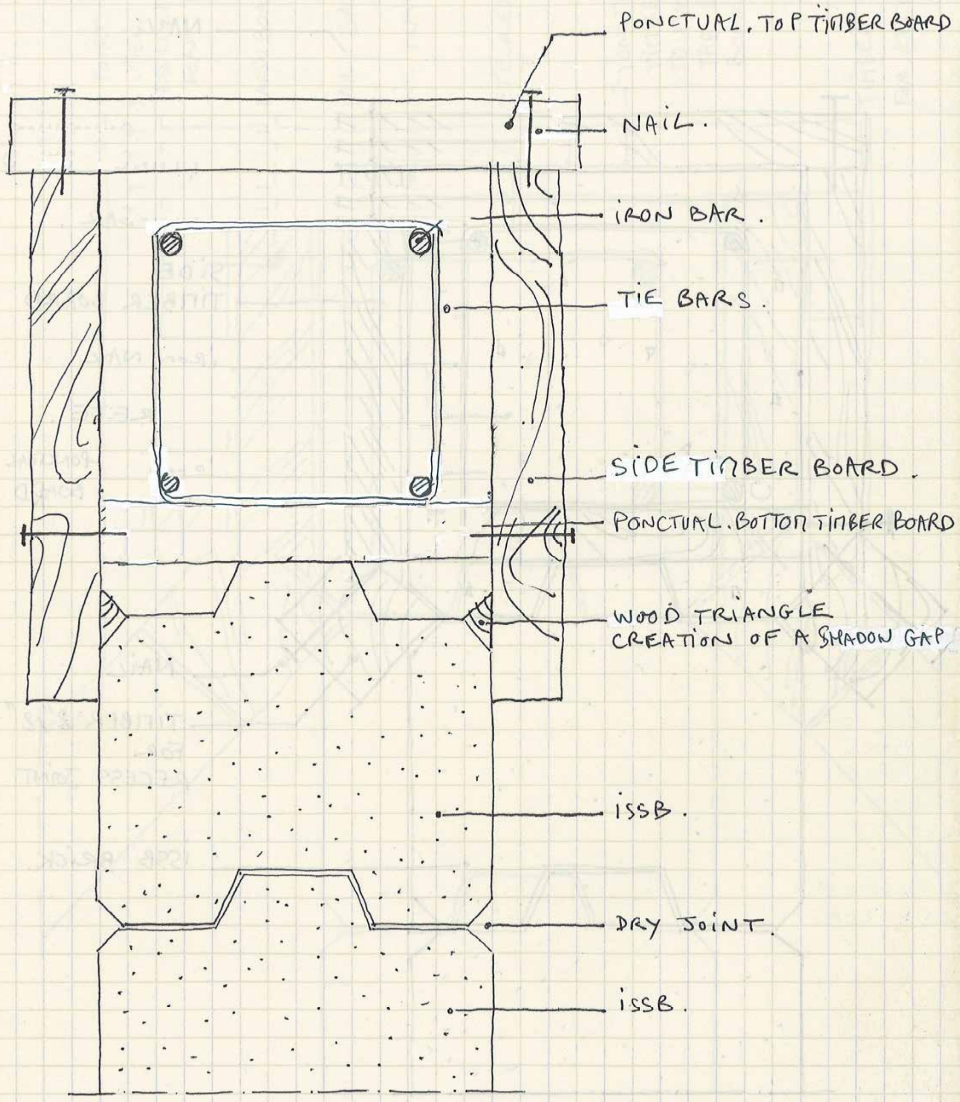
NOTA:
- IRON BARS TO BE NAILED TO IRON NAILED WITH WIRE.
- CONCRETE COVER TO BE MINIMUM OF 2 CM.
- FOAM BOARDS COMPRESSION ON ISSB WALL TO BE DONE ACCORDING TO USUAL METHOD OF CONTRACTOR.
- WOOD TRIANGLE FOR CREATION OF RECESS JOINT IS A MAJOR DETAIL



TURKANA 4. PAGE 17. TYPE C. PM. 03.02.18

TYPE C. RING BEAM DETAIL. SCALE 1/2. OPTION 01.

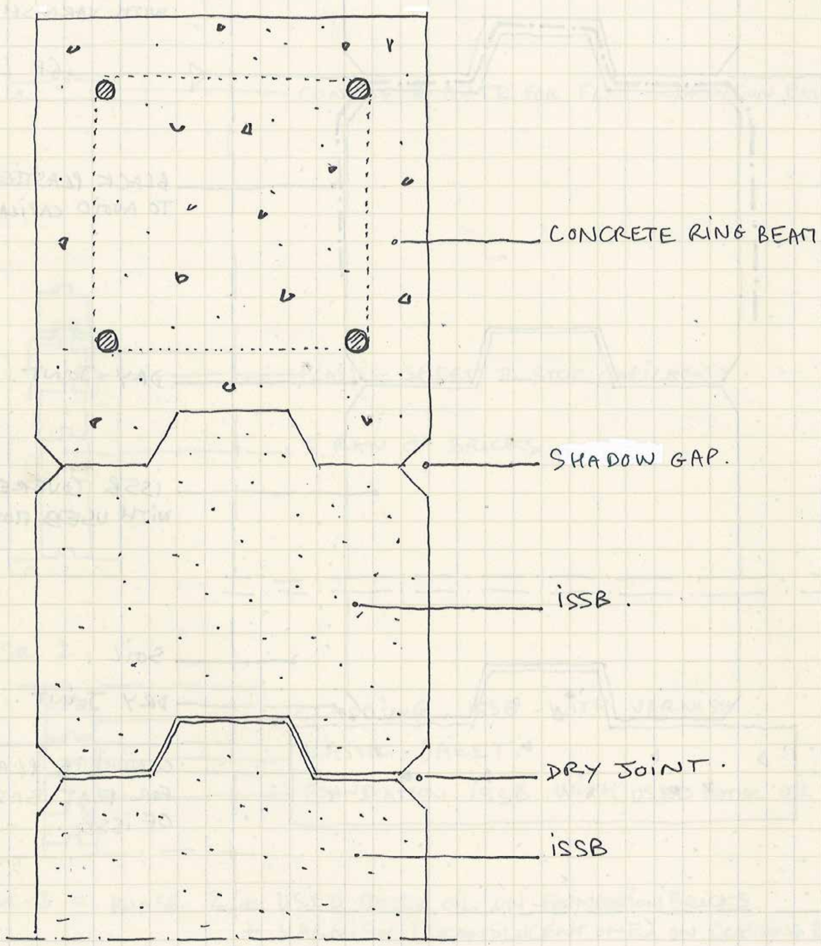
FORMWORK. PHASE 1.



TURKANA4. PAGE 20. TYPE C. PM. 03.02.18

TYPE C. RING BEAM DETAIL. SCALE 1/2. OPTION 01.

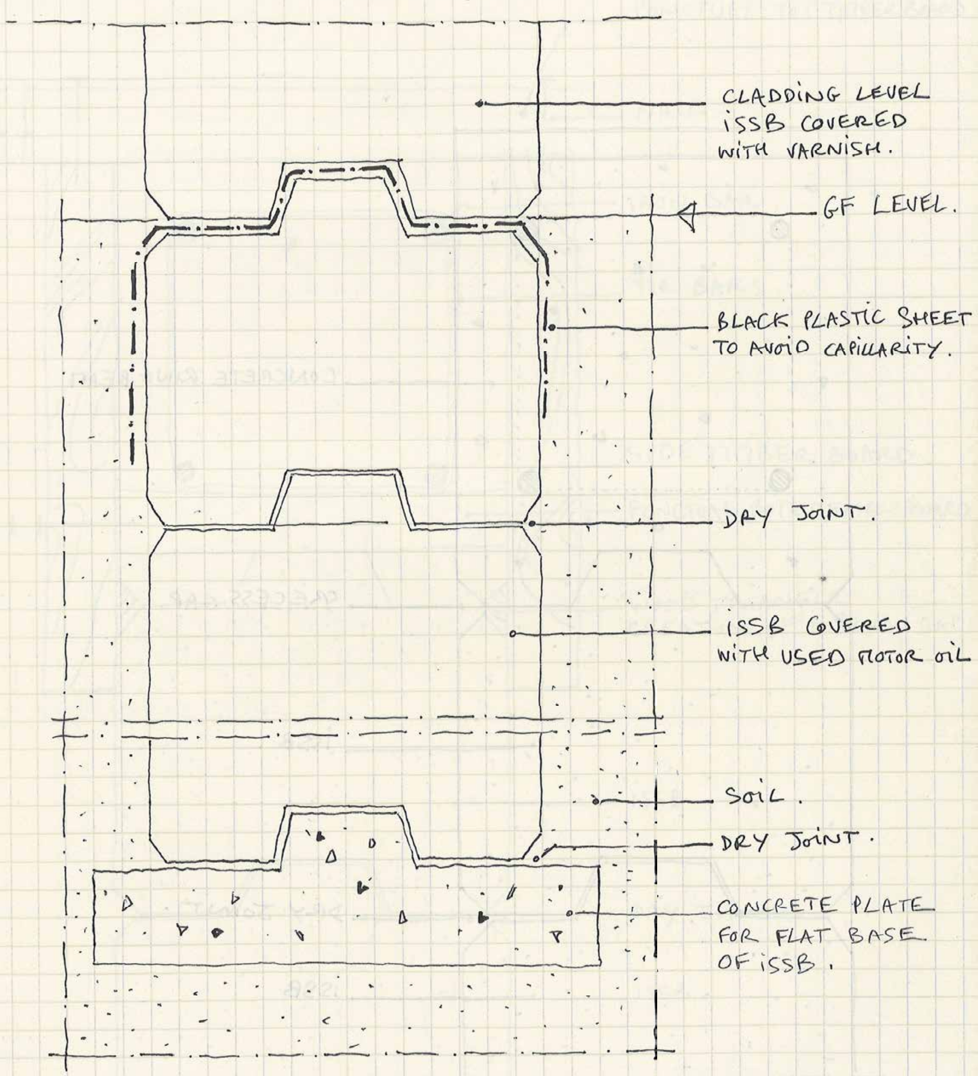
AFTER FORMWORK. PHASE 2.



TURKANA4. PAGE 21. TYPE C. PM. 03.02.18

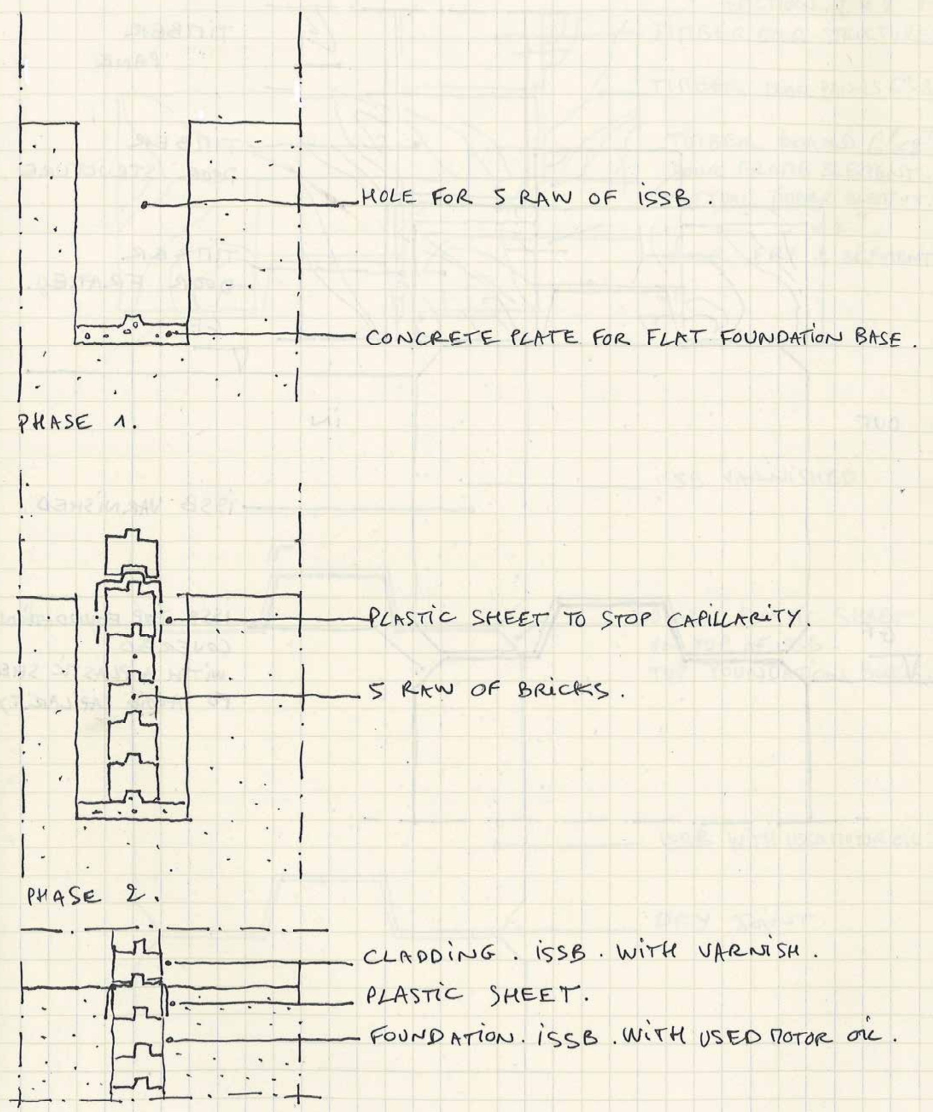
TYPE C. FOUNDATION DETAIL. SCALE 1/2.

GRADING. PHASE 1.
BRICKS ON GRADING. PHASE 2.
WATERPROOFING ON TOP BRICKS. PHASE 3.



TURKANA 4. PAGE 22. TYPE C. PM. 04.02.18

TYPE C. FOUNDATION DETAIL. NO SCALE.



PHASE 3 = PHASE 2 + USED MOTOR OIL ON FOUNDATION BRICKS
+ VARNISH (TRANSLUCENT ONE) ON CLADDING BRICK

TURKANA 4. PAGE 23. TYPE C. PM. 04.02.18

Inspired by the Context

Mission M08. February 2018

Type A. Windows, Door and Floor

February 1st. The Paper Tube House is on its way to completion. Since the lower edge of the roof is quite low, and so that we can open up the house completely, we build a double-leaf door rather than a single-leaf as previously planned.
During the previous mission, there was a small windstorm (Fig. 48), which we had previously experienced in October 2017. I later learned that this is commonly referred to as a 'dust devil'.
The American Meteorological Society (AMS) defines this phenomenon as "a small but vigorous whirlwind, usually of short duration, rendered visible by dust, sand, and debris picked up from the ground. (...) They are best developed on a hot, calm afternoon with clear skies, in a dry region when intense surface heating causes a very steep lapse rate of temperature in the lowest 100m of the atmosphere ".[22]
This led me to improve our origami ventilation detail with a twine system for a more sturdy closing position in case of a dust devil (Fig. 49).

February 12th to 14th. We install the door and the last two windows (Fig. 50). When they are closed, they are barely visible, which is the effect we wanted to achieve. The camouflage is perfect (Fig. 51).

Fig. 48. Type A. January 18th. A 'dust devil' in Turkana

Fig. 49. Type A. Origami ventilation detail. From open to closed position to protect from sandstorms

Fig. 50. Type A. Weaving and nailing the tubes onto the timber frame door with fine wire

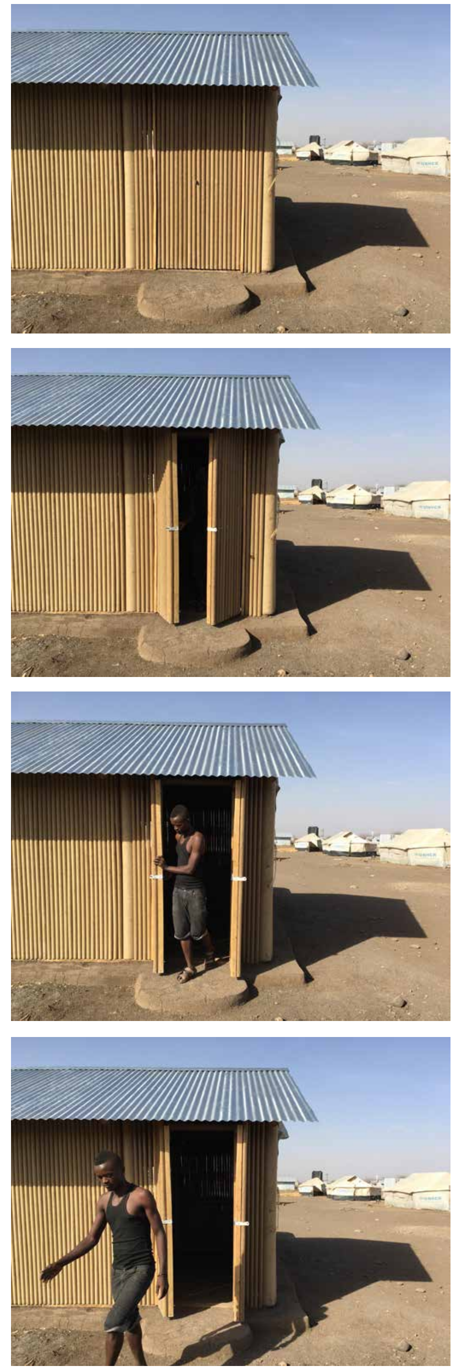


Fig. 51. Type A. Door opening demonsration

Step 1. Mixture of local soil + water applied by hand

Step 2. Mixture of laguna soil + local soil and water

Step 2bis. Application of the mixture by hand

Fig. 52. Type A. Coating of the floor. Process in two steps over 48 hours. South Sudenese tradition

Fig. 53. Type A. Step 1 close-up. Coating the floor

Over the same period, Nyaluak Choul from South Sudan is here with her friend, Nyaoum Patote[23]. They start to daub the floor inside the Paper Tube House with mud (Fig. 52). This is done in two steps:

1. Apply a mixture of soil and water to act as the thick, primary layer
2. After the first layer is dry, apply a thin mixture of laguna soil mixed with water for a smooth finish

The work is done entirely by hand (Fig. 53). We learnt that you have to keep your hands wet to prevent the soil from sticking to them.

Type B. Replacing the Bricks

February 1st. I noted the poor-quality, twisted wood being used for construction of the ISSB House (Type C) during the January mission. Today, I discover that the burnt bricks used for the Wood Frame House (Type B) are also poor-quality. They are observably not properly burnt. Most, if not all of them, are also disintegrating.

Fig. 54. Type B. Replacing the bricks. Left. deconstruction. Middle: replacement. Right: completion

Fig. 55. Type B with new bricks from Kakuma, and the tarpaulin origami system

You can easily dig a hole in the walls with your bare hands. In addition, the mortar has not cured properly: some pieces of cement are falling apart. We are left with only one option: to dismantle all the bricks and restart the work with better-quality bricks. From that experience, I understand that strong ongoing supervision will be required for the production and assembly of the next set of bricks. I also understand that there is lack in quality control for the construction of local houses. Perhaps this is linked with the nomadic culture of the Turkana locals, who are not used to creating permanent houses, as they are used to moving, or perhaps it is because refugees are not often seen to reside permanently in a location, since they supposedly have the opportunity for repatriation. One thing is certain: it will take time to raise awareness amongst the people and achieve quality outcomes, if we are to move towards building more permanent shelters in the long term.

February 12th. The new burnt bricks arrive, so we carefully dismantle the old bricks. Gilbert and Sedar use a piece of twine nailed to the timber frame to align the bricks (Fig. 54). The work takes four days.

February 16th. We complete the house with tarpaulin origami structure installed on the short façades of the house in the same way as we did it with the Paper Tube House (Fig. 55). No wind, no dust; the sky is clear.

Fig. 56. Type C. Concrete ring beam with formwork

Fig. 57. Type C. Concrete ring beam without formwork

Type C. Restarting from Scratch

Following a risk assessment, Gilbert and the team dismantle all the houses to restart the building process. This time, the stacking of ISSB walls is not hurriedly conducted by a group of ten people. It is carefully and consciously done by two people, block by block, allowing for the checks at critical points to ensure the verticality of the walls.

February 1st. Almost all the blocks have been repositioned. As we are not able to find good-quality materials, such as straight timber, the engineer advises us to replace the wooden ring beam with a reinforced concrete one for better stabilization. I ask Gilbert to rebuild the walls before we do it, as the team had forgotten to insert a plastic sheet between the foundation blocks and the walls – an important detail to prevent the capillary rise of water.

On the first day back in Nairobi, I draw the detail with the plastic sheet on top of the foundation wall and send it to Gilbert to experiment on site. We both decide to cover the block touching soil with used motor oil to avoid any long-term damage from water impregnation.

I sketch a section of the formwork with a piece of wood between the blocks and the concrete ring beam, to create a clear demarcation between the two different materials. This is a commonly used architectural detail, but proves to be a real challenge to achieve with few resources. After several exchanges with Gilbert and Sedar about the challenges of cutting a square wood section in half to create triangle recess joints, we agree to use a metal bar instead.

Lastly, I make a new proposal for the wooden frame interlocking detail for the window and the door with a bigger piece of wood for increased strength.

February 12th. I am back on site to check on the ongoing work. The formwork is still in place (Fig. 56).

February 13th. We remove the formwork (Fig. 57) and apply used motor oil to the first row of blocks above the plastic sheet, to ensure the bottom of the wall is waterproof. I realise that it would have been more efficient to put the plastic sheet 15cm above the ground level to prevent flash floods.

Two days later, we work on the door and the window frames. Just like before, I figure out a better detail on site than the one I imagined on paper. We break the interlocking section of the blocks to obtain a flush surface. Simultaneously, we create the frames with available timber boards using dove-tail connections. Lastly, we install the frames and nail them to the walls. Two nails are introduced on each side of the interlocking detail. The nails serve to stop unwanted movement of the wood frame (Fig. 58).

Fig. 58. Type C. Completion of a window frame

Fig. 59. Type C. Joining a roof window to a truss with simple hinges

From Origami Detail to Roof Windows

After a month of several sandstorms, the origami tarpaulin construction on the Paper Tube House looks like a ragged piece of fabric. The sand carried by the wind creates scour marks on its surface like sand paper. I conclude that tarpaulin is too fragile for these climatic conditions if it is left exposed.

February 15th. While we are placing the trusses we have already built on the Type C House, I have an idea inspired by the door detail: we will add 'roof windows' to the trusses still to be installed on the short façades (Fig. 59).

The term 'roof windows' refers to triangular shutters made out of wood, and filled with wooden boards or a metal sheet. These shutters can be closed in case of a sandstorm.

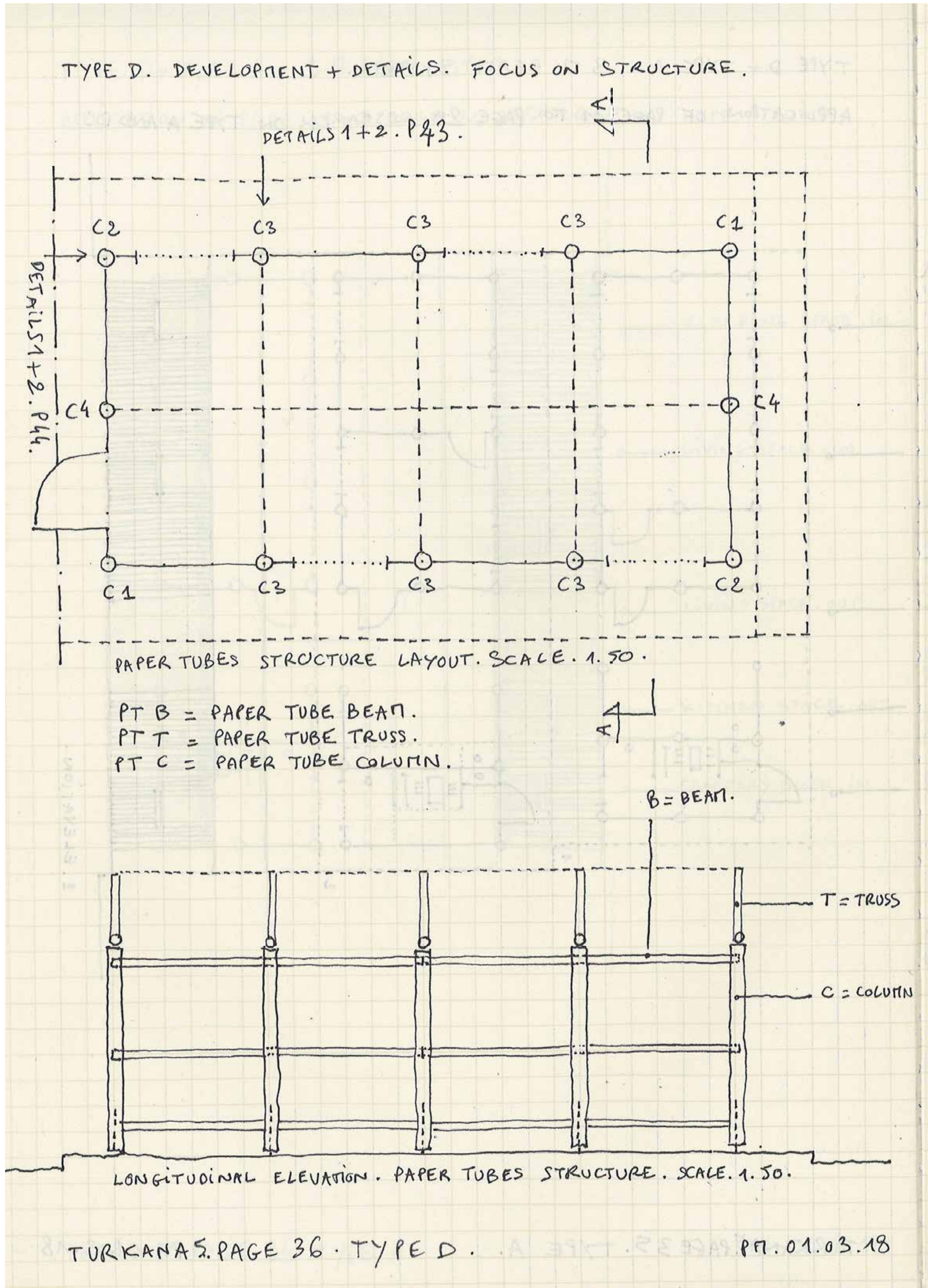
This idea has been in my mind since the beginning of November 2017, but I had to first try the origami system. On site, the material and the tools bring you to these discoveries. Contextual constraints act as catalysts for imagination.

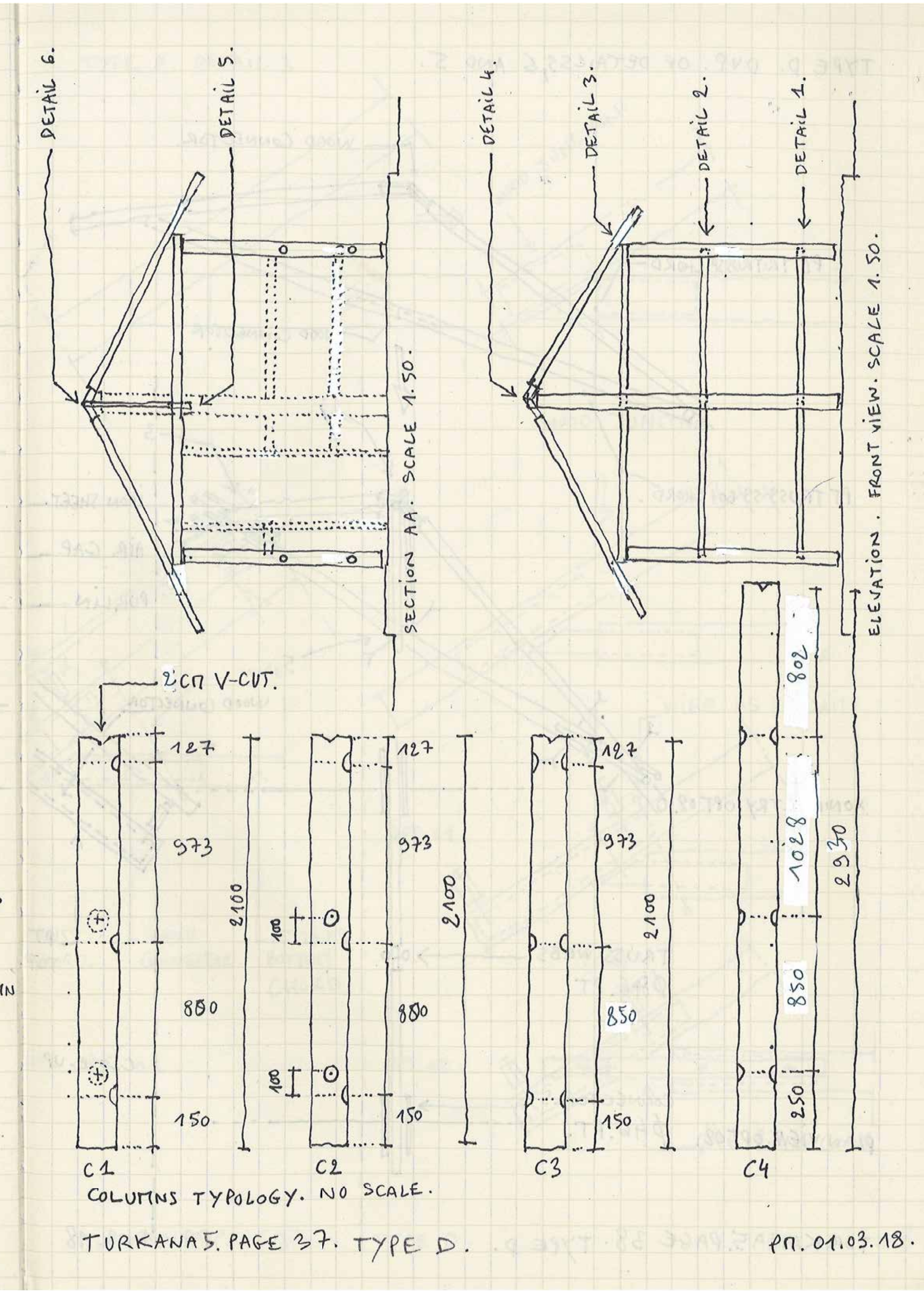
Lessons Learned. Challenges Over Time

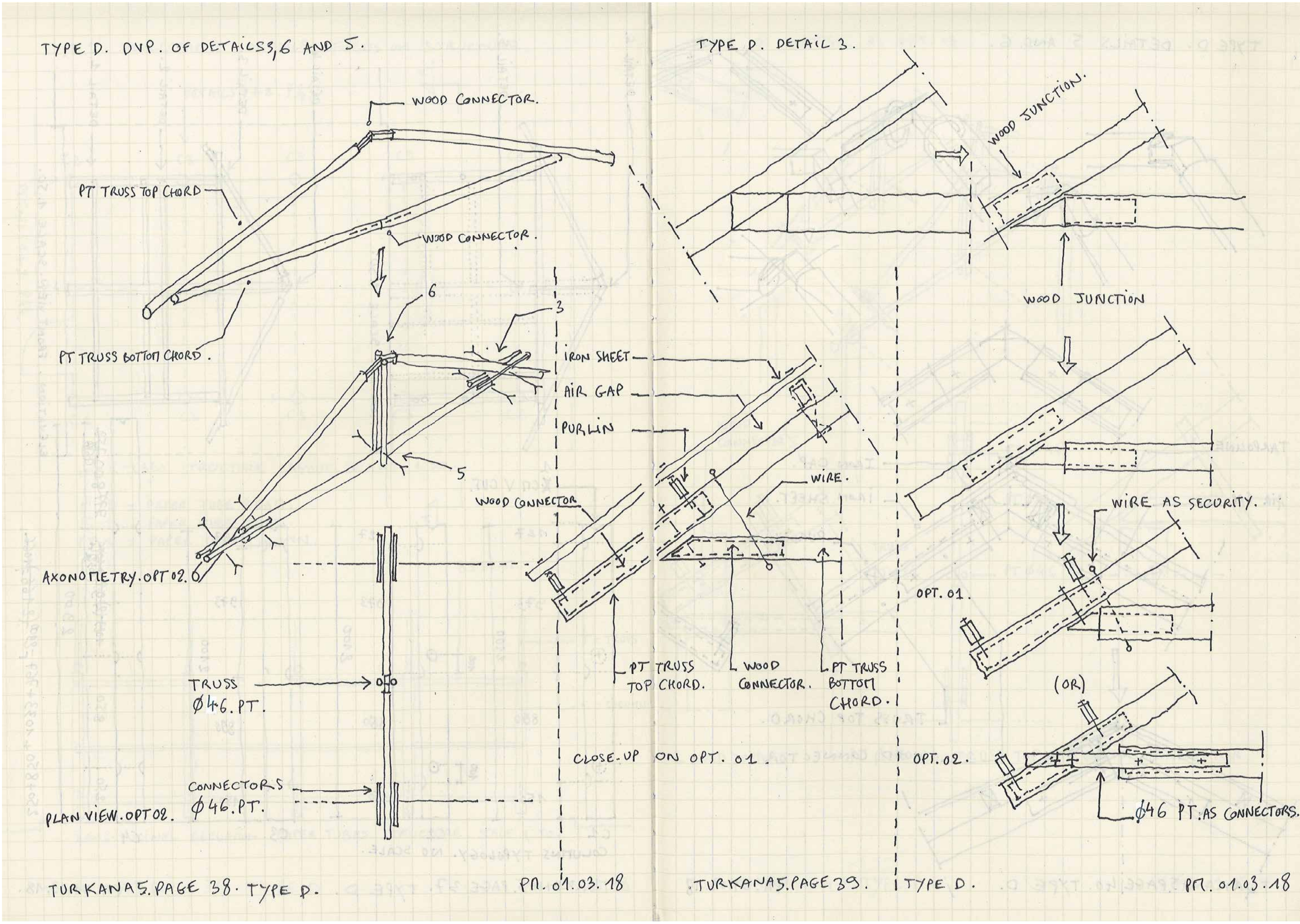
In previous missions, we encountered a lack of tools and construction knowledge. This time, we came to understand the unique environmental challenges in Turkana. Our pilot houses will not last if we do not prepare them for the windstorms that are common in the region. The idea of 'roof windows' is surely one of the best so far, and it arose as a solution to the problem of the tarpaulins disintegrating over time.

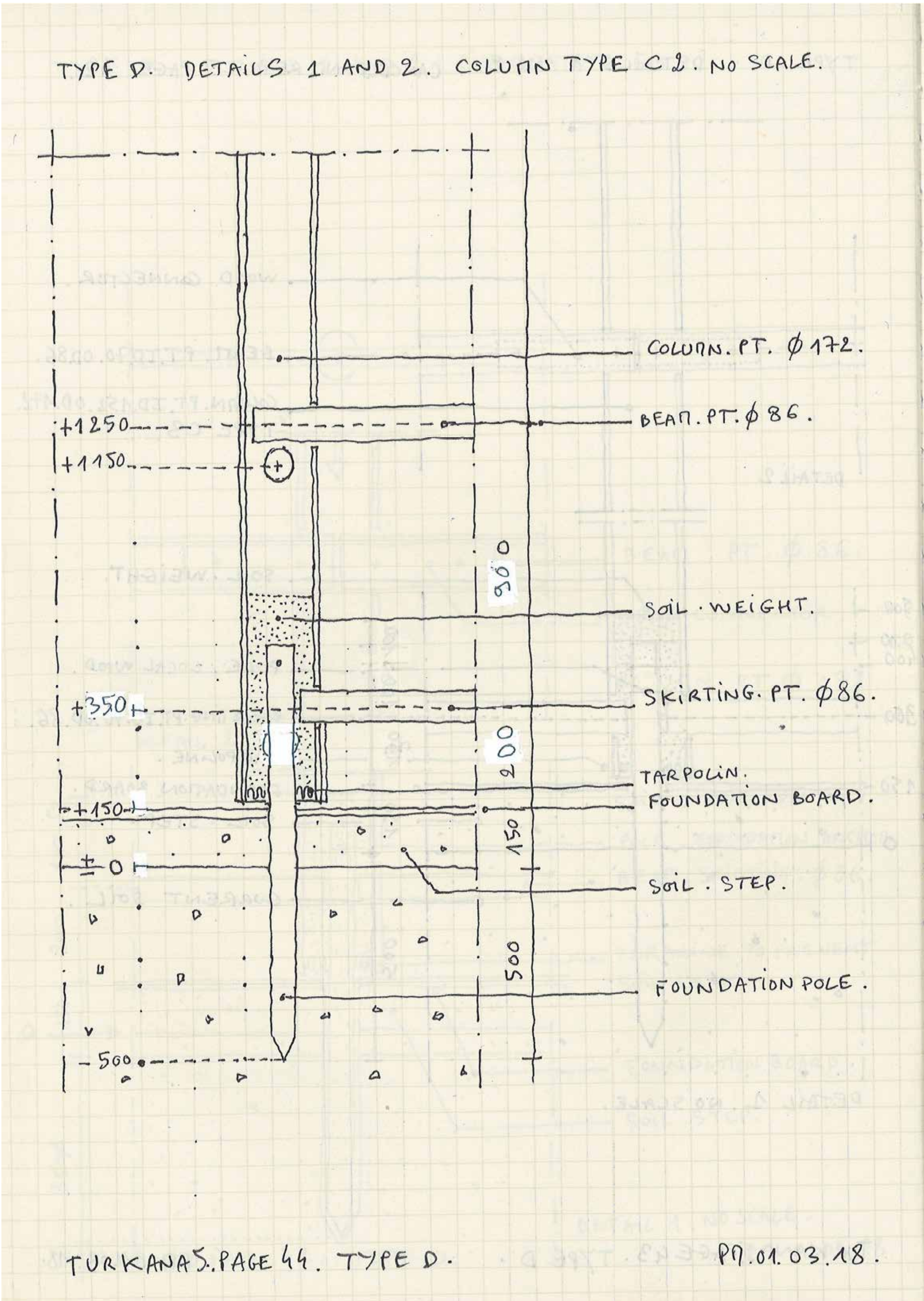
Although the impact of the environment is a lesson learned for our architectural process, it is not the only one. When I met Nyaluak Choul, the South Sudanese woman, I did not think that she would be so willing to participate in construction. Her traditional knowledge and skills add a lot of new dimensions to our project, through the direct inclusion of traditional construction processes. However, several challenges remain. It is difficult to anticipate how the environment and the cultural practices of occupants will impact on our designs over time. We have become more aware of this while working on site. Confronting these challenges is not a constraint, but a source of inspiration for the construction of the houses.

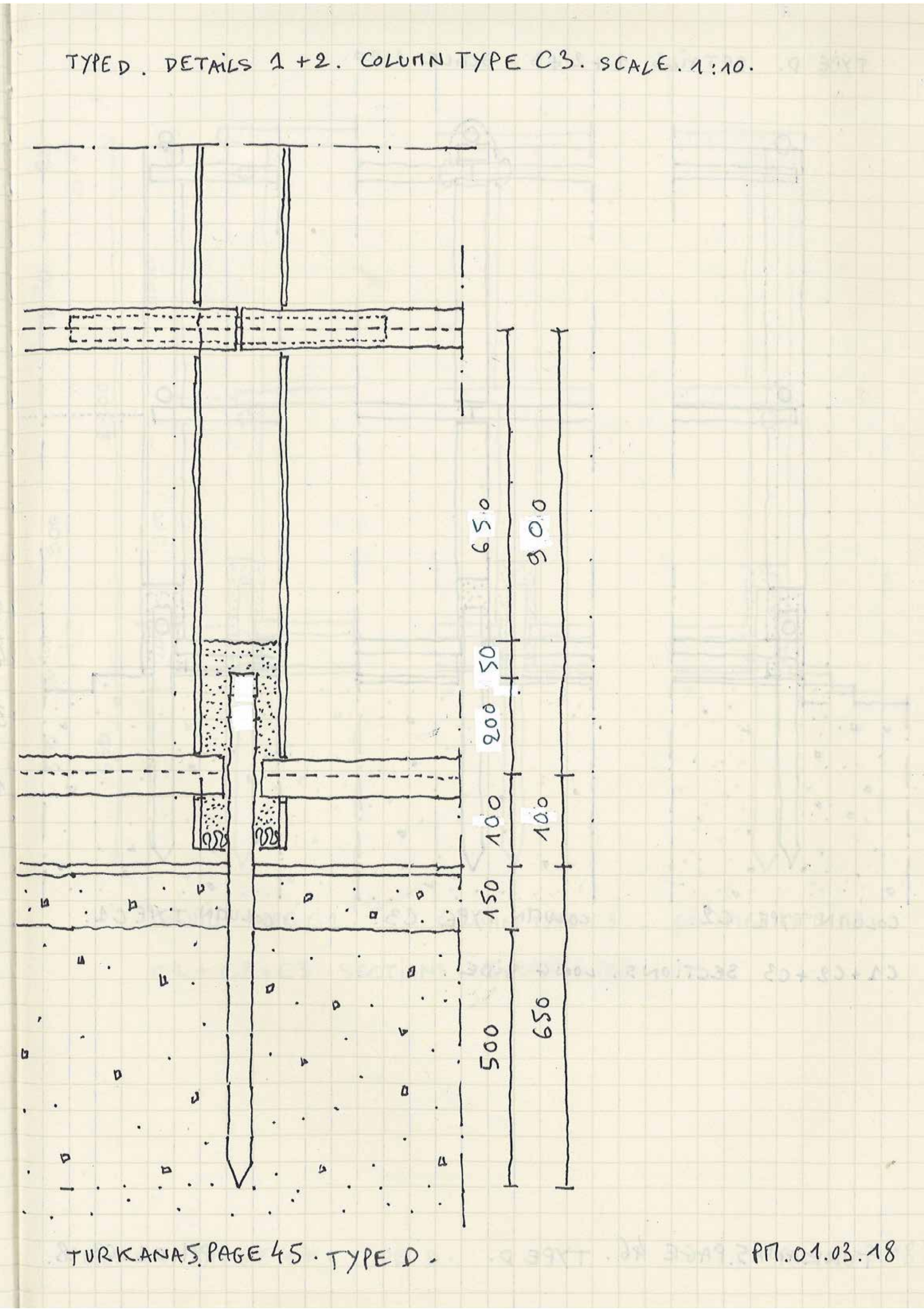
Following pages: extracts from Sketchbook n°5. Details for Type D construction


TYPE D. DEVELOPMENT + DETAILS. FOCUS ON STRUCTURE.
DETAILS 1+2. P43.
DETAILS 1+2. P44.
A
C2
C3
C3
C3
C1
C4
C4
C1
C3
C3
C3
C2
PAPER TUBES STRUCTURE LAYOUT. SCALE. 1. 50.
PT B = PAPER TUBE BEAM.
PT T = PAPER TUBE TRUSS.
PT C = PAPER TUBE COLUMN.
B = BEAM.
T = TRUSS
C = COLUMN
LONGITUDINAL ELEVATION. PAPER TUBES STRUCTURE. SCALE. 1. 50.
TURKANA 5. PAGE 36. TYPE D.
PM. 01.03.18

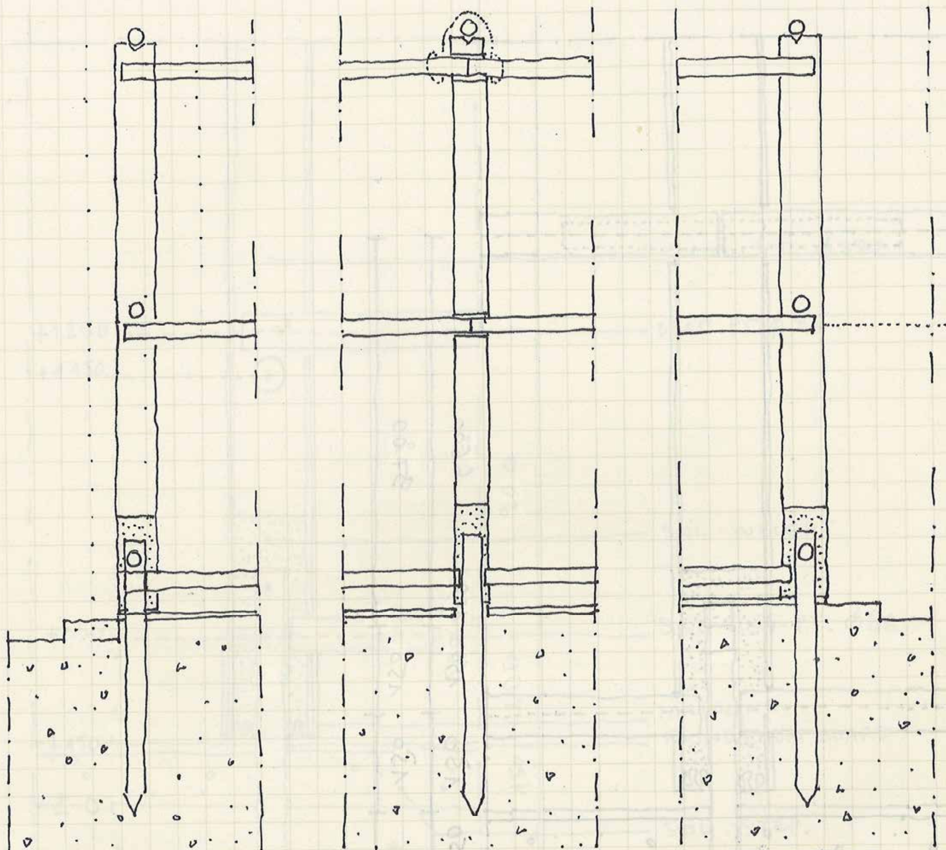

DETAIL 6.
DETAIL 5.
DETAIL 4
DETAIL 3.
DETAIL 2.
DETAIL 1.
SECTION AA. SCALE 1. 50.
ELEVATION. FRONT VIEW. SCALE 1. 50.
2 CM V-CUT.
127
973
2100
880
150
100
C1
C2
C3
C4
850
802
1028
2930
250
COLUMNS TYPOLOGY. NO SCALE.
TURKANA 5. PAGE 37. TYPE D.
PM. 01.03.18.


TYPE D. DVP. OF DETAILS 3,6 AND 5.
WOOD CONNECTOR.
PT TRUSS TOP CHORD
WOOD CONNECTOR.
PT TRUSS BOTTOM CHORD.
6
3
5
AXONOMETRY. OPT 02.
TRUSS
Ø46. PT.
CONNECTORS
Ø46. PT.
PLAN VIEW. OPT 02.
IRON SHEET
AIR GAP
PURLIN
WOOD CONNECTOR
WIRE.
PT TRUSS TOP CHORD.
WOOD CONNECTOR.
PT TRUSS BOTTOM CHORD.
CLOSE-UP ON OPT. 01.
TURKANA5. PAGE 38. TYPE D.
PM. 01.03.18
TYPE D. DETAIL 3.
WOOD JUNCTION.
WOOD JUNCTION
WIRE AS SECURITY.
OPT. 01.
(OR)
OPT. 02.
Ø46 PT. AS CONNECTORS.
TURKANA5. PAGE 39.
TYPE D.
PM. 01.03.18


TYPE D. DETAILS 1 AND 2. COLUMN TYPE C2. NO SCALE.
COLUMN. PT. Ø172.
BEAM. PT. Ø86.
+1250
+1150
900
SOIL. WEIGHT.
+350
SKIRTING. PT. Ø86.
200
TARPOLIN.
FOUNDATION BOARD.
+150
150
±0
SOIL. STEP.
500
FOUNDATION POLE.
-500
TURKANA5. PAGE 44. TYPE D.
PM.01.03.18.

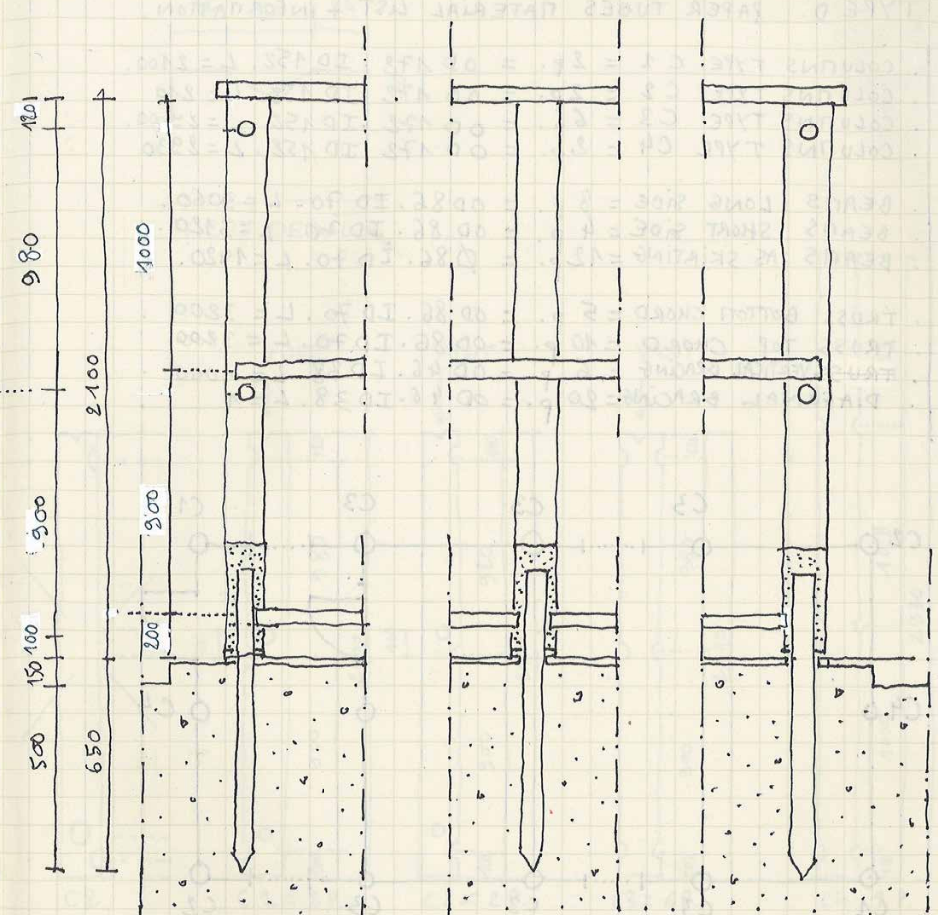

TYPE D. DETAILS 1+2. COLUMN TYPE C3. SCALE. 1:10.
650
900
50
200
100
100
150
500
650
TURKANA5. PAGE 45. TYPE D.
PM.01.03.18.

TYPE D. DETAILS 1+2+3. SCALE 1:20.



COLUMN TYPE C2. COLUMN TYPE C3. COLUMN TYPE C1.

C1+C2+C3 SECTIONS. LONG SIDE.



COLUMN TYPE C1. COLUMN TYPE C3. COLUMN TYPE C2.

C1 + C2 + C3 SECTIONS. SHORT SIDE.

TURKANAS.PAGE 46. TYPE D. PM.01.03.18.

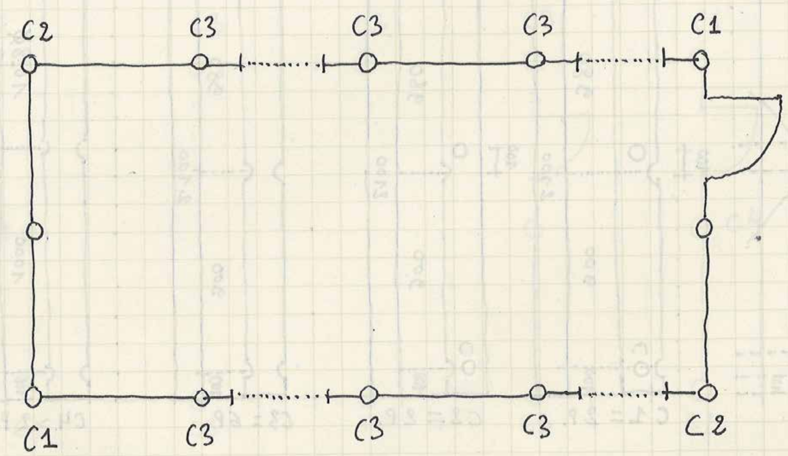
TURKANAS.PAGE 47. TYPE D. PM.02.03.18

TYPE D. PAPER TUBES LIST + INFORMATION.

- COLUMNS TYPE C1 = 2 P = OD 172. ID. 152. L 2100.
- COLUMNS TYPE C2 = 2 P = OD 172. ID 152. L 2100.
- COLUMNS TYPE C3 = 6 P = OD 172. ID 152. L 2100.
- COLUMNS TYPE C4 = 2 P = OD 172. ID 152. L 2930.

- BEAMS LONG SIDE = 8 P = OD 86. ID 70. L 3060.
- BEAMS SHORT SIDE = 4 P = OD 86. ID 70. L 3120.
- BEAMS SKIRTING = 12 P = OD 86. ID 70. L 1420.

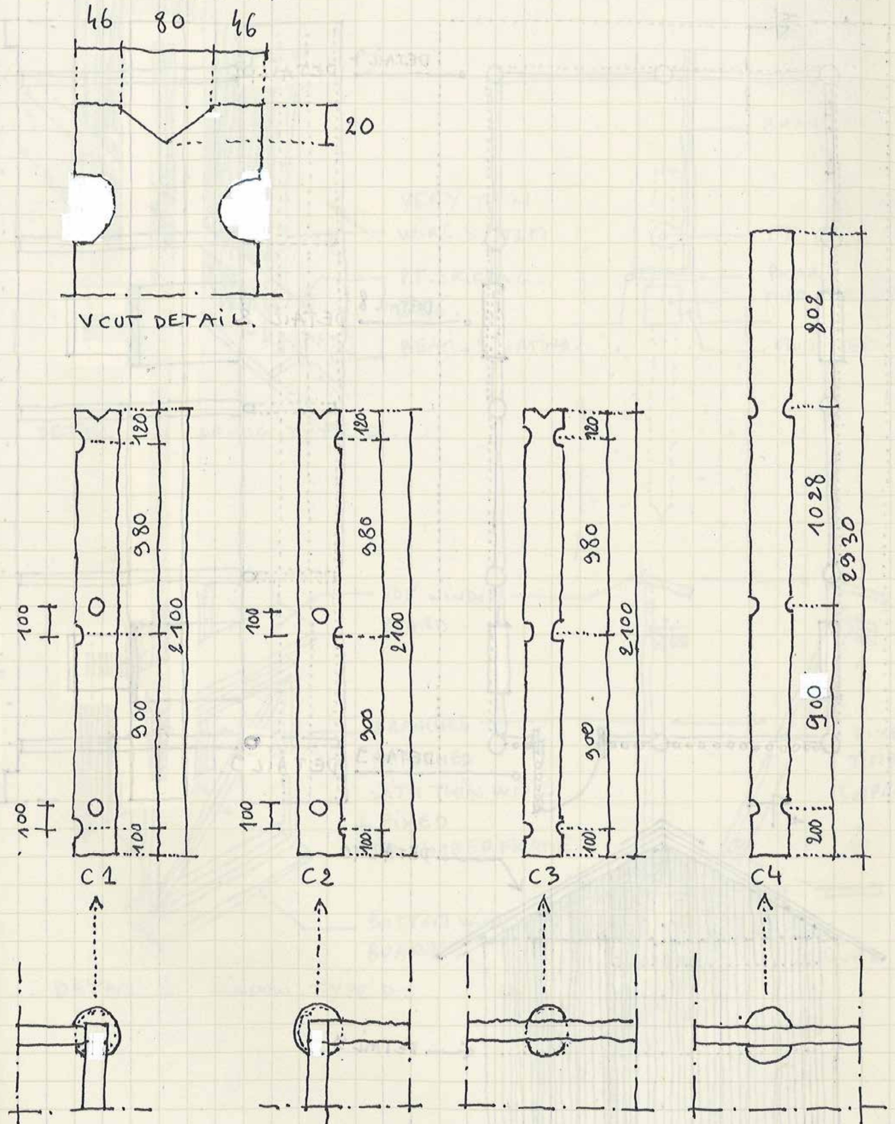
- TRUSSES BOTTOM CHORD = 5 P = OD 86. ID 70. L 3200.
- TRUSSES' TOP CHORD = 10 P = OD 86. ID 70. L 2800.
- VERTICAL BRACING = 6 P = OD 46. ID 38. L 1000.
- DIAGONAL BRACING = 20 P = OD 46. ID 38. L 1000.



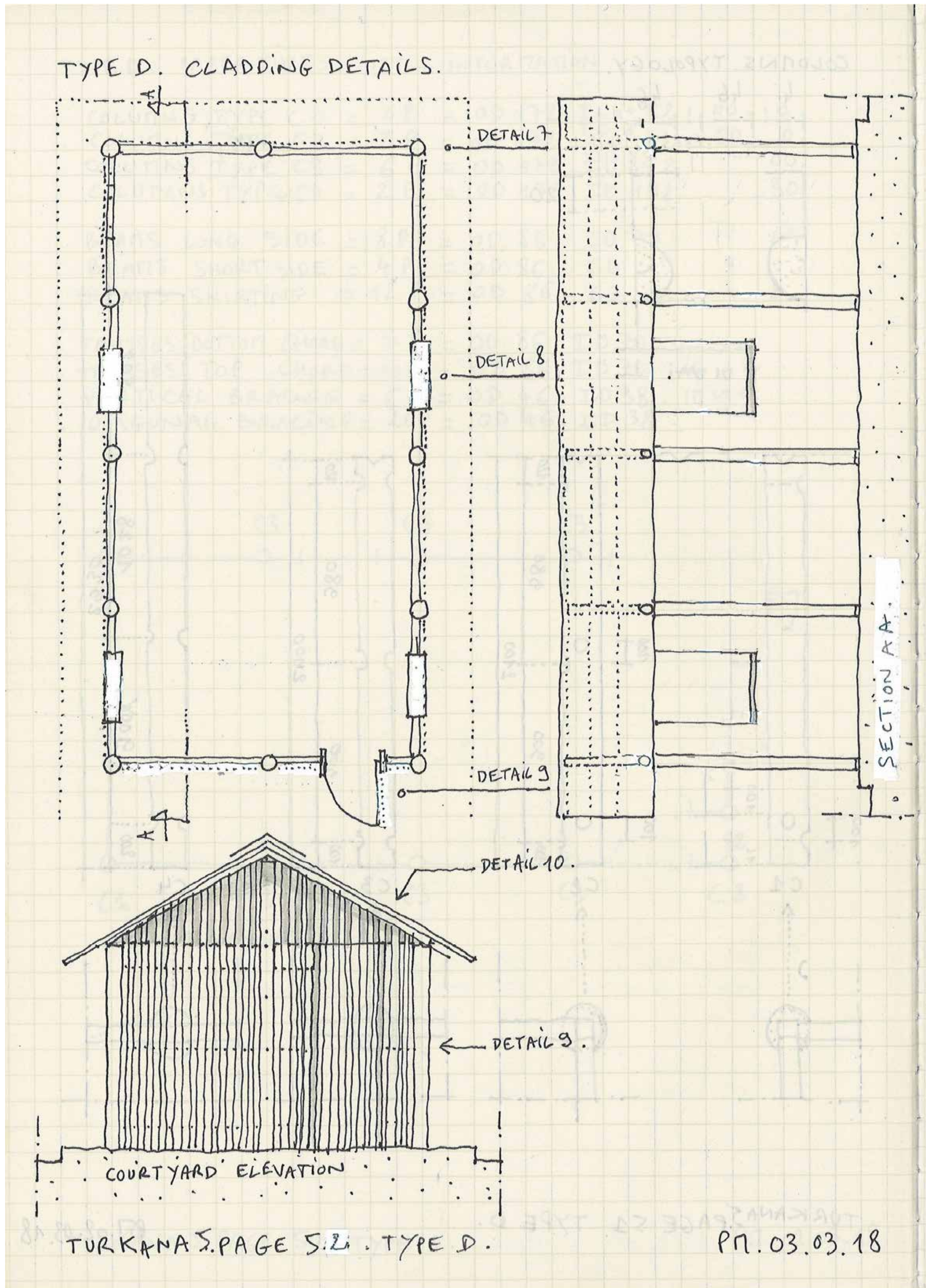
TYPE A LAYOUT.

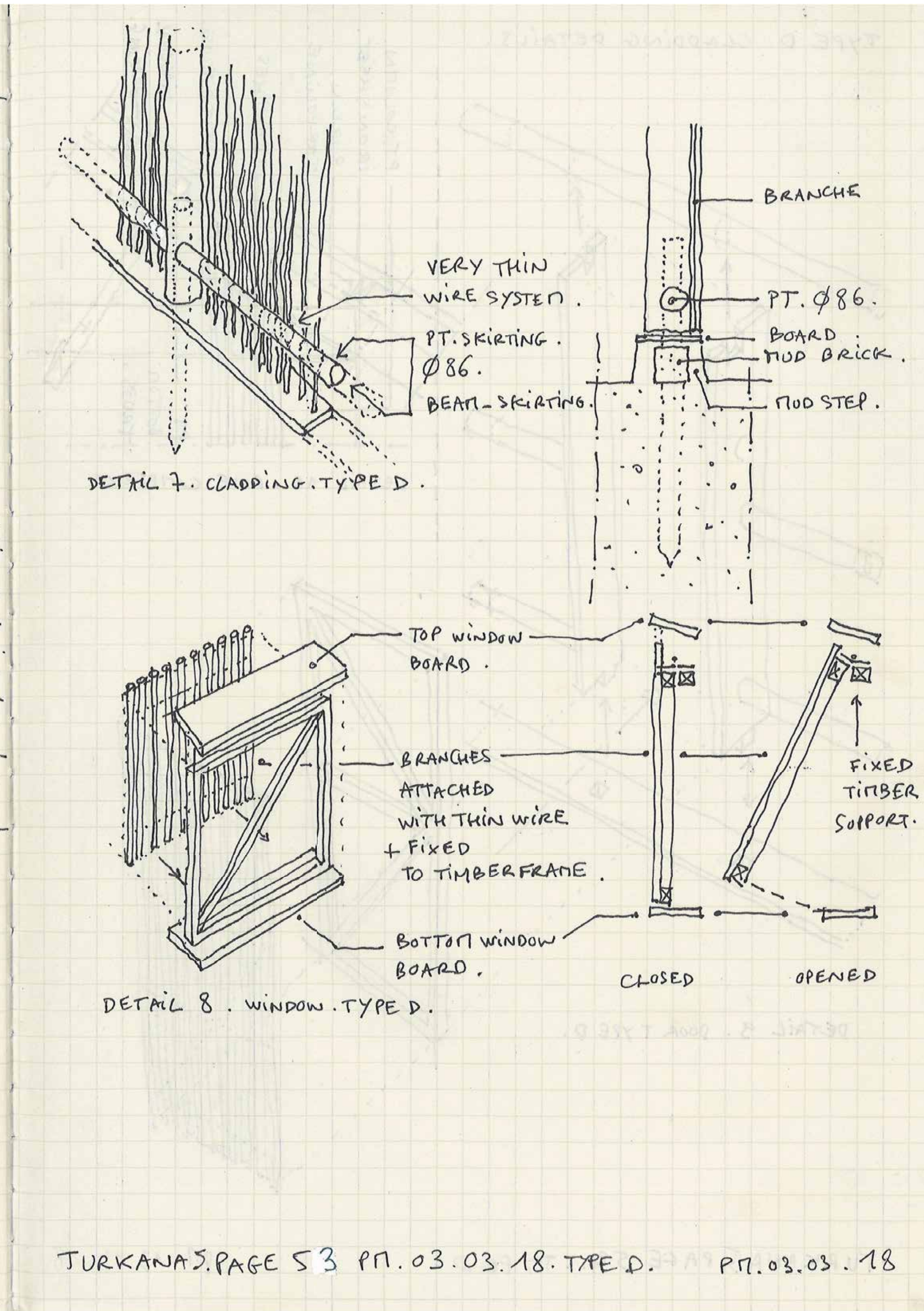
TURKANA 5. PAGE 50. TYPE D. PM. 02.03.18

COLUMNS TYPOLOGY.



TURKANA 5. PAGE 51. TYPE D. PM. 02.03.18


TYPE D. CLADDING DETAILS.
DETAIL 7
DETAIL 8
DETAIL 9
SECTION A.A.
DETAIL 10.
DETAIL 9.
COURTYARD ELEVATION
TURKANAS.PAGE 52. TYPE D.
PП. 03.03.18


VERY THIN
WIRE SYSTEM.
PT. SKIRTING.
Ø86.
BEAM-SKIRTING.
DETAIL 7. CLADDING. TYPE D.
BRANCHE
PT. Ø86.
BOARD.
MUD BRICK.
MUD STEP.
TOP WINDOW
BOARD.
BRANCHES
ATTACHED
WITH THIN WIRE
+ FIXED
TO TIMBERFRAME.
BOTTOM WINDOW
BOARD.
FIXED
TIMBER
SUPPORT.
CLOSED
OPENED
DETAIL 8. WINDOW. TYPE D.
TURKANAS.PAGE 53 PП. 03.03.18. TYPE D.
PП. 03.03.18

A Brand New Experience with Paper Tubes

Mission M09. March 2018

In September 2017, during his video presentation to UN-Habitat, Shigeru Ban committed to designing a fourth pilot house based on the results of my research on the vernacular architecture of the region.
We believe that South Sudanese and Turkana architecture have some similarities. Both build mainly with what is available within the surrounding environment. During a meeting in Paris, while we are looking for a brand-new design, I propose to replace the paper tube cladding with branches. Shigeru Ban likes the idea. Catherine Arot, our Turkana architect, would be able to coordinate the weaving of the branches and the cladding assembly of the new pilot house. Gilbert and I will work on the improvement of the paper tube structure. The fourth pilot will henceforth be known as the Branch House.

Type D. The Influence of the Type A Experience

March 1st. I attempt to sketch the details of this new pilot house, while recording

Fig. 60. Type C. General view

Fig. 61. Type C. Close-up of the roof windows

each failure from the Paper Tube House construction process.

I start with an inventory of the different kinds of paper beam and paper columns available, an inventory similar to the one prepared earlier by VAN's team for the Paper Tube House. As we struggled to install a double door on the previous house, I position the entrance on the short façade to create a single leaf door. When we tied the tubes together for the Type A cladding, we had to install a skirting that was not designed to ensure the bottom attachment of the tubes. This time, I plan the holes in the columns to install a paper tube skirting. We face the same challenge of creating the "V cut" on the top of the columns on site for connecting to trusses - I will ask Statpack to do it in the factory.
The second step is the assembly of trusses. While on site we realised that it is difficult to tie several tubes together with wire. Furthermore, there were issues with the top triangular portion of the short façade because the top chords were not on the same plane as bottom chords. In light of this failure, I place all structural elements on the same plane. As the wood connectors were a success on site, I design junctions with Prosopis branch connectors. Their sections fit perfectly with the inner section of the paper tube beams.
The third detail that I want to improve is the interlocking of columns with the foundation poles, including the new paper tube skirting. A piece of fabric found on site, positioned to cover the bottom of the column, is the perfect way to prevent the loss of sand and ballast. Although I will not be able to link the paper tube skirting together as I do for the upper beams, a simple interlock with the column should work. I draw different types of connections between the columns and the beams, and prepare to update the paper tube inventory.

March 2nd. I resume my research, collating an inventory of drawings of all types of paper tubes, including their dimensions and quantities needed of each type. The drawings show the position of holes and the "V-cut" on each column type. Statpack will refer to the inventory document when manufacturing the paper tubes. Lastly, I prepare the cladding details, including the door and the window systems. The cladding of the short façade is simple, as the bottom and the top trusses are on the same plan.

Type C. A Repeat of the Experience with Type B

In the first week of March, heavy rains affect the cladding of the ISSB pilot house (Type C). During this emergency, Gilbert varnishes the entire surface of the façade to protect the blocks. The varnish visually accentuates the poor quality of blocks (Fig. 60). From a soft pink, the "bad blocks" turn to dark brown when varnished. This experience tells us two things:

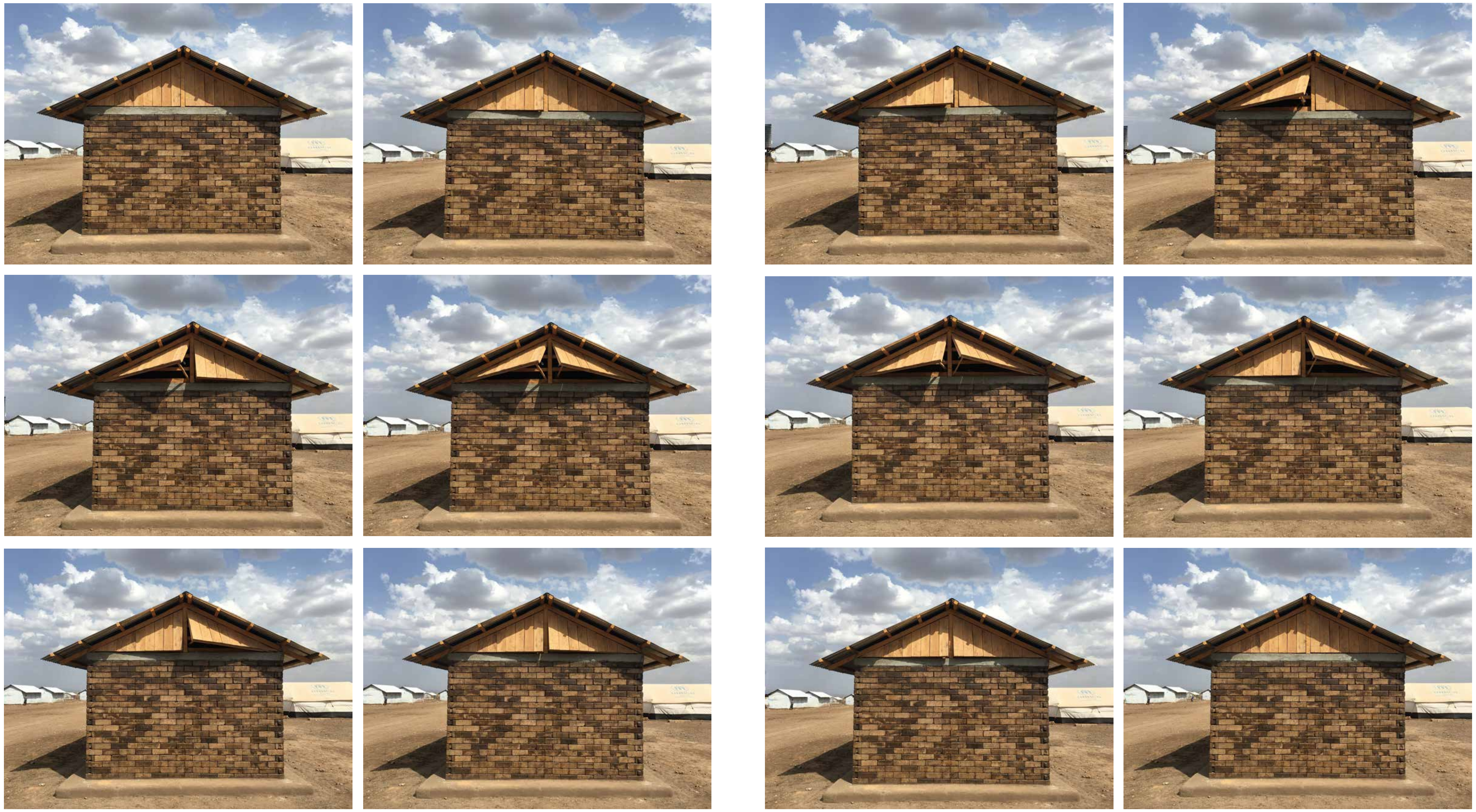


Fig. 62. Type C. Roof windows oparated from inside

Fig. 63. Type D. Levelling the foundation boards with mud bricks

Fig. 64. Type D. Nailing the foundation boards to the Prosopis poles

1. It remains difficult to find good quality soil in Kalobeyei for this construction technique.
2. When the blocks were fabricated at the end of last year, the team did not eliminate the poor-quality ones.

The poor-quality blocks which were included within the delivery reveals negligence to quality. It is not only an aesthetic issue, but is also one of maintenance and structural integrity. Normally, we would not need to varnish the walls. Unfortunately, since they are a mixture of poor- and good-quality blocks, this pilot house will need to be re-varnished before every rainy season. This negligence makes the house unaffordable due to its high maintenance cost.
As with the first burnt bricks used for cladding of the Type B House, our project is impacted by the lack of quality control of construction materials in Kalobeyei. When the project moves to a larger scale of production, ideally we will implement a quality control procedure for the fabrication of materials and the construction of the houses, as we do in all other architectural projects. This is essential to ensure constructions are safe and structurally sound, especially in mass production processes.

In contrast, the roof windows installed bring out the personality of the house. When opened, they allow air to flow through the louvres, creating an efficient ventilation system. If a wind storm or heavy rain threatens, they can be closed. This works as we expected, and I am very pleased! The only additional detail will be to build a small ladder[24] for occupants to stand on to reach the windows from inside (Fig. 61 and 62). See ladder p. 423.

Type D: Foundations and Bundles of Branches

March 13th. We start the foundations of the Branch House. The procedure is the same as the Type A: 1m poles, half buried, half above the ground level, are positioned every 1.5m; mud bricks are positioned in a staggered pattern between the poles; then some timber boards positioned on the mud bricks and nailed to the poles (Fig. 63 and 64).

Every morning, before we work on the foundations, we go to the market to buy bundles of Proposis branches. One bundle contains approximately 30 branches. We need more than 80 bundles for the cladding, but fewer than ten bundles are available each day. Every morning before sunrise, Turkana men go on foot to pick the branches far away from Kalobeyei and bring them to sell in the market. It is difficult to get a sufficient number of bundles, and since our quality control is strict we only use the straightest branches.

Fig. 65. Type B. 'Origami window' asssembly with canvas

Type B. Canvas Origami

March 27th. We replace the tarpaulin in the Type B ventilation system with a canvas fabric from Nairobi. I want to test the longevity of the Origami Ventilation System with a thicker fabric, to see if this will resist wind storms better (Fig. 65 and 66).

Type D. Assembling the Paper Tube Structure

March 27th. The paper tubes are delivered from Nairobi, and we assemble them in the morning. This time, interlocking the beams with the columns is easy because the holes in the columns are larger to account for the thickness of the varnish. This is great because if the holes are even a millimetre too small, this could pose a challenge for the assembly (Fig. 67 and 68).

March 28th. Early in the morning, we slot the paper tube structure onto the Prosopis poles, with the assistance of a few neighbours. We experience the same issue as we did with the Type A assembly - ropes are necessary to stabilize the structure. It is

Fig. 66. Type B. A completed 'Origami window'

Fig. 67. Type D. Beams and columns. Test before assembly

Fig. 68. Type D. Beams and columns. Assembly in progress

Fig. 69. Type D. Truss fabrication. Assembly of the kingpost

Fig. 70. Type D. Truss to be attached to the main structure with bent wire

important to note here that the flexibility of a paper tube does not mean it lacks strength: “It folds but does not break”[25]. With its sand-weighted base, the paper tube structure can perfectly resist the unexpected Turkana sandstorms.

In the afternoon, Gilbert begins assembling the trusses. First, we lay out timber at the end of the tubes where they will need to be nailed down, something we learned to do during the construction of the Type A House. The tricky part is creating the junction of the top two trusses. In addition to timber at the end of the tubes, we add a board on both sides to prevent them from rotating. We take advantage of the gap between the two boards to introduce a thin paper tube that works structurally as the kingpost. There is no need for a thick section because it mainly works in traction. Gilbert digs a hole in the center of the bottom truss to interlock the tube and prevent any movement. His tools are a hammer and a single nail with its head crushed (see p. 422). At the end of the day, we have only completed one truss, but we are now confident about the construction details. The Type D truss is as light as the Type A one (Fig. 69 and 70).

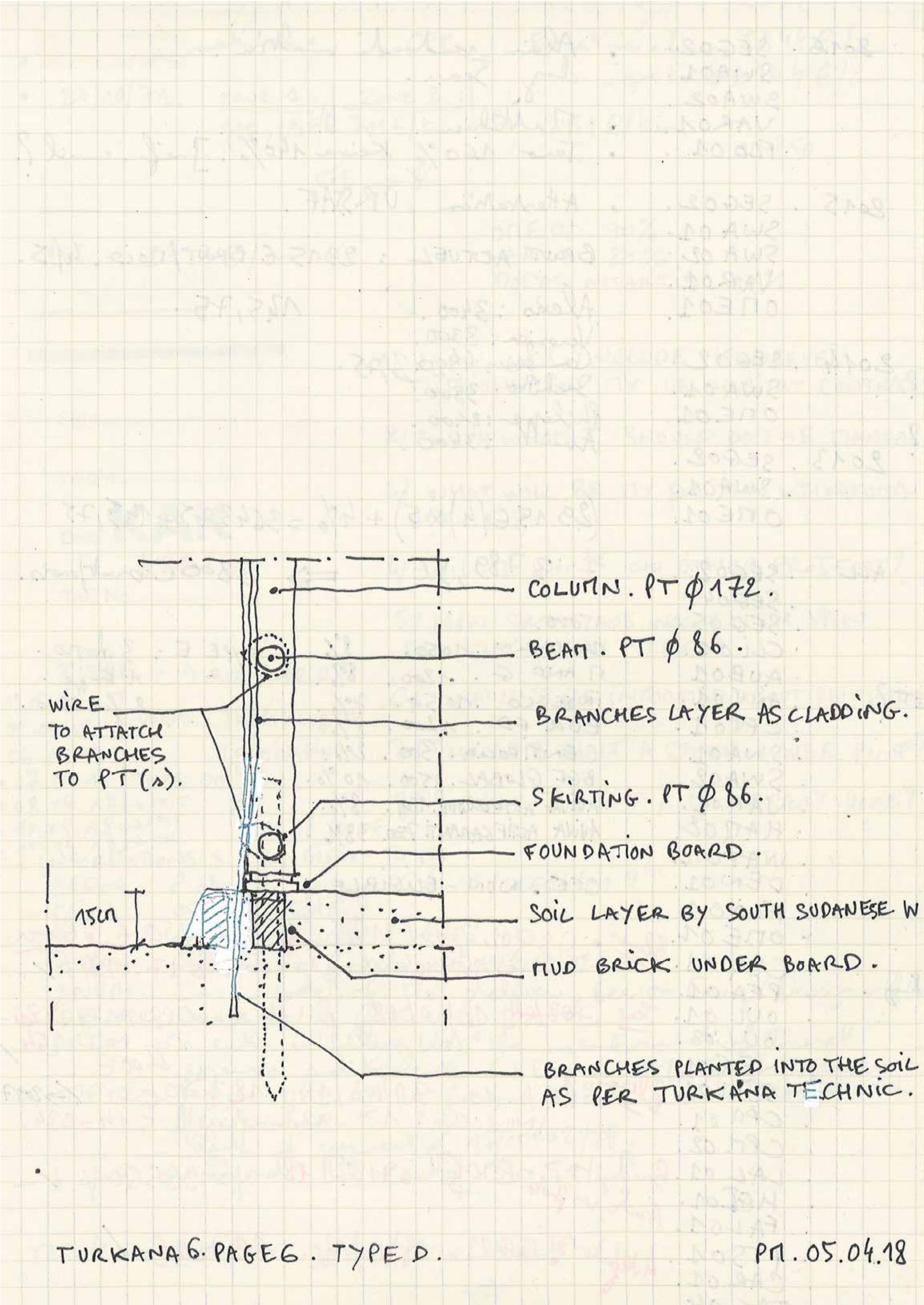
March 29th. We continue building the trusses. For the short façades, we use the

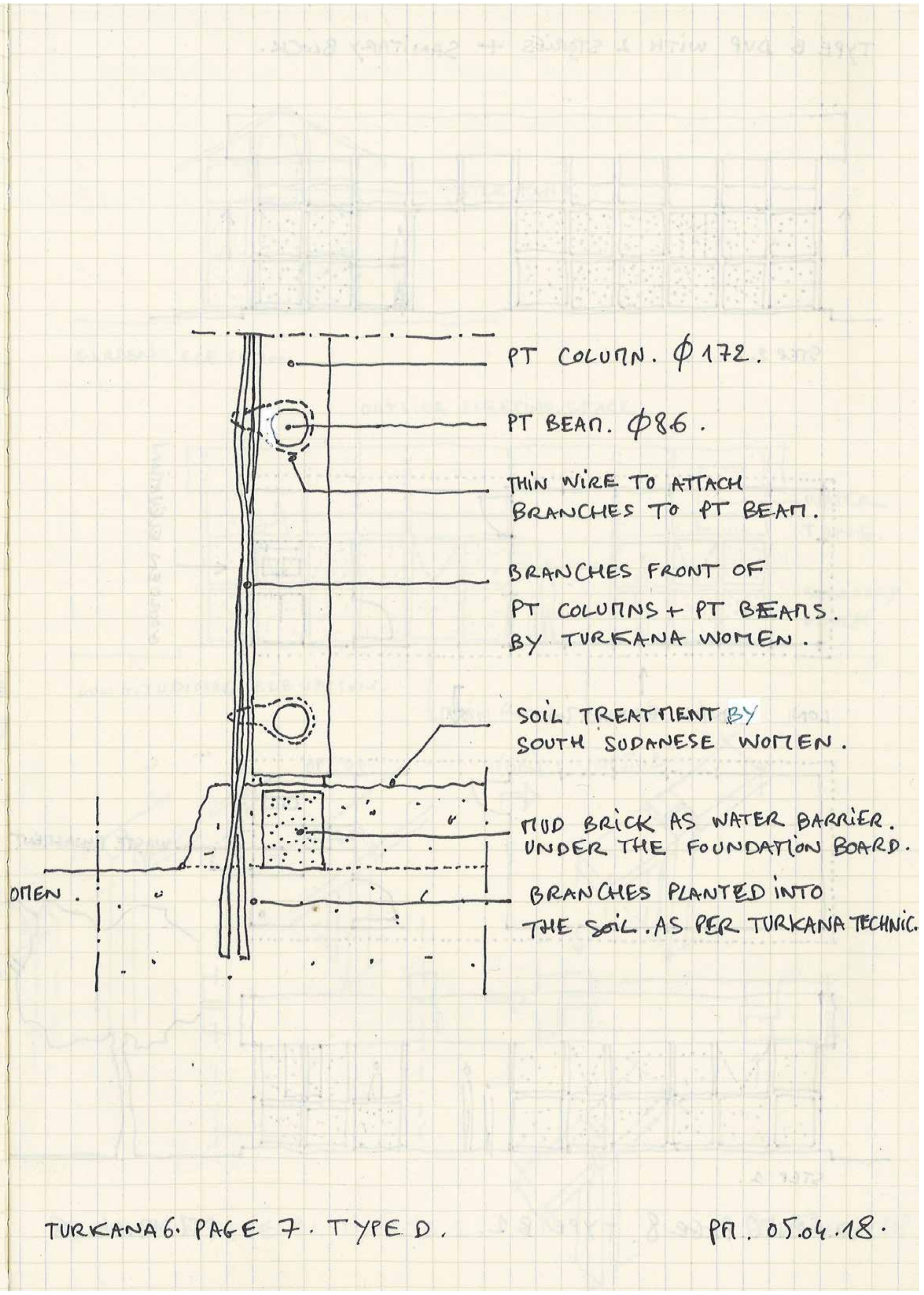
central column as the kingpost, and as we already have the bottom trusses crossing the column, we need to find a way to fix the top trusses directly onto the cladding structure. We imagine a new detail without changing the principle. Gilbert manufactures a sort of big “wood nail” detail, incorporating a wood connector on both sides for the interlocking of the top trusses. The complete assembly involves the interlocking of the truss paper tube into the central column truss, which sits on the two side columns.
In the following days, Gilbert and the team assemble the roof with the exact same method as we did it on the Type A House. He folds and nails the tarpaulin around the purlins to ensure a 5cm air gap between the tarpaulin and the corrugated iron sheets still to be attached.

Lessons Learned. A Slow But Sure Construction Process

When working on the cladding for Type C, we experienced the same issue we previously experienced in building Type B - poor-quality blocks. This reinforced my growing conviction that all materials should be inspected prior to construction to ensure they are of good quality.
Before the assembly of the Type D structure, we carefully chose our materials, tools and construction methods. The step-by-step description of the truss fabrication process may seem tiresome, but shows the gradual development of the design. It was an empirical method: I drew some details, modified them on site, redrew the details including our construction progress, and again improved the assembly on site. Step by step, we moved from a complicated roof structure to a minimalistic one, at least in appearence.

Following pages: extracts from Sketchbook n°6. Preparatory detail for weaving branches


COLUMN. PT Ø172.
BEAM. PT Ø86.
WIRE TO ATTACH BRANCHES TO PT(S).
BRANCHES LAYER AS CLADDING.
SKIRTING. PT Ø86.
FOUNDATION BOARD.
15CM
SOIL LAYER BY SOUTH SUDANESE WOMEN.
MUD BRICK UNDER BOARD.
BRANCHES PLANTED INTO THE SOIL AS PER TURKANA TECHNIC.
TURKANA 6. PAGE 6. TYPE D.
PM. 05.04.18


PT COLUMN. Ø172.
PT BEAM. Ø86.
THIN WIRE TO ATTACH BRANCHES TO PT BEAM.
BRANCHES FRONT OF PT COLUMNS + PT BEAMS. BY TURKANA WOMEN.
SOIL TREATMENT BY SOUTH SUDANESE WOMEN.
MUD BRICK AS WATER BARRIER. UNDER THE FOUNDATION BOARD.
BRANCHES PLANTED INTO THE SOIL. AS PER TURKANA TECHNIC.
TURKANA 6. PAGE 7. TYPE D.
PM. 05.04.18.

Construction in the Rain

Mission M10. April 2018

Paper Tube Waterproofing Issues

In the first days of April, upon my arrival at the building site, I discover a desolate landscape (Fig. 71). The soil is soaked through. The paper tubes are damaged. Looking closely at pilot houses A and D, I observe some water damage at the edges of the tubes and on the overlapping areas. The varnish may have not been applied properly during manufacturing in Nairobi (waterproofing paper tubes was a first for Statpack), and it turns out that the tubes have been roughly transported by truck with barely any protection. We face again the issue of quality control, from the production of materials to their delivery on site.

Some time ago, Adarsh from Statpack visited the site to explore the possibility opening a factory in Kakuma. Unfortunately, as electricity is produced primarily by generators, he concluded that a paper tube factory in the area would not be profitable. Production can only be done in Nairobi for the moment. Furthermore, even with better varnish application, protecting the tubes during transportation will increase their price per unit.

We are faced with some hard questions: Should we continue to experiment with paper tubes at Kalobeyei New Settlement, trying to overcome the existing challenges? Should we discontinue this option for production at a larger scale? The decision is a difficult one, considering all the research investment into the paper tubes. We have spent a lot of time tweaking their assembly to improve the

Fig. 71. Type A. April 8th. Paper tube cladding in the pouring rain

Fig. 72. Type D. The roof structure

Fig. 73. Type D. The 'Nail Pivot' in action. Detail by Gilbert and Sedar

design and efficiency of construction. Moreover, the Paper Tube House is locally recognised as an exciting design and an aesthetic success. Ultimately, paper tube manufacturing could be a business opportunity for a local contractor, but this would only be possible with power from the main electricity grid rather than from generators.

Type D. The Nail Pivot

April 5th. We try to protect the paper tubes from the rain with some plastic sheet and leftover tarpaulin. I check the roof details (Fig. 72) and we start to work on the wooden frame of the door and windows. This time, we manage to replicate my sketch exactly. This door detail is a duplicate of the window frames.

April 6th. Gilbert and Sedar invent the 'nail pivot' for the window system – a stroke of genius! They pick up some bottle caps from the ground, drill a hole in the center of each one with a nail, and then introduce the bottle cap between the frame and window, ensuring a smooth rotation of the window. To secure it, they twist the nail to prevent it from moving laterally (Fig. 73).

April 7th. The river that leads to the site is flooded. We are not able to travel for work and I am stuck in the World Food Programme compound.

Type D. Attaching Branch Cladding in the Rain

April 8th. We manage to reach the site. We treat the base of the branches against termites with some used motor oil (Fig. 74), and dig a 20cm trench around the house to clad the branches on the paper tube structure.
Catherine Arot is here with us. After the oil treatment, she aligns the branches carefully onto the exterior walls of the house, and she sews them to the paper tube beams with the fine wire (Fig. 75). She replicates the same technique she used for the Type A cladding.
On another side of the house, Gilbert is working on the cladding of the windows. He selects the straightest branches, then nails them on the timber frame. The intended effect is camouflage. I want the windows to "disappear" when closed into the cladded branches. It is a detail directly inspired by the Paper Tube House. At the end of the day, it rains cats and dogs. Our progress is very slow. Due to the strong winds, some people move the tarpaulin protection to the exposed paper tubes to protect it.

April 9th. The rain stops, and strong sunlight returns. Catherine and I continue to clad the house with branches, and Gilbert works on the entrance door. Even in

Brundles of Prosopis branches. Each bundle contains 30 branches (approx.)

Used motor oil was applied to the end of each branch and dried.

Soaking the branches in used motor oil

Fig. 74. Type D. Termites treatment for the Prosopis branches before being weaved onto the PT structure

Fig. 75. Type D. Attaching branches to the Paper tube structure

Fig. 76. Type D. Attaching the branches in muddy conditions

good weather conditions the cladding takes a long time, much longer than was previously expected. This is because we need to apply several layers of branches to create a semi-opaque façade.

April 10th. The heavy rains return in the afternoon. We pursue our work in the mud, totally soaked. The conditions are extremely difficult. For the first time in Turkana, I am freezing cold (Fig. 76).

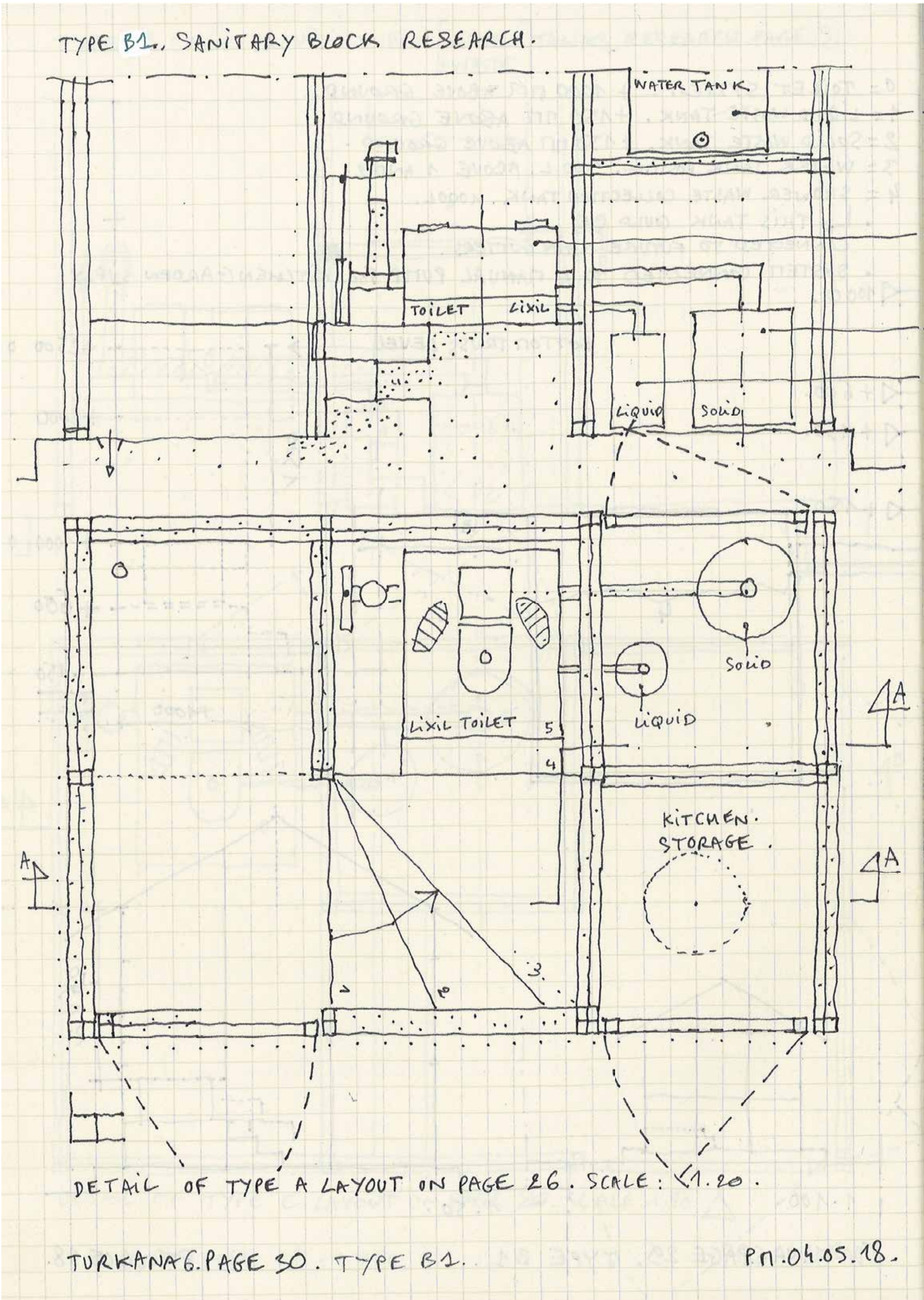
Lessons Learned. Turkana Architecture in the Rain

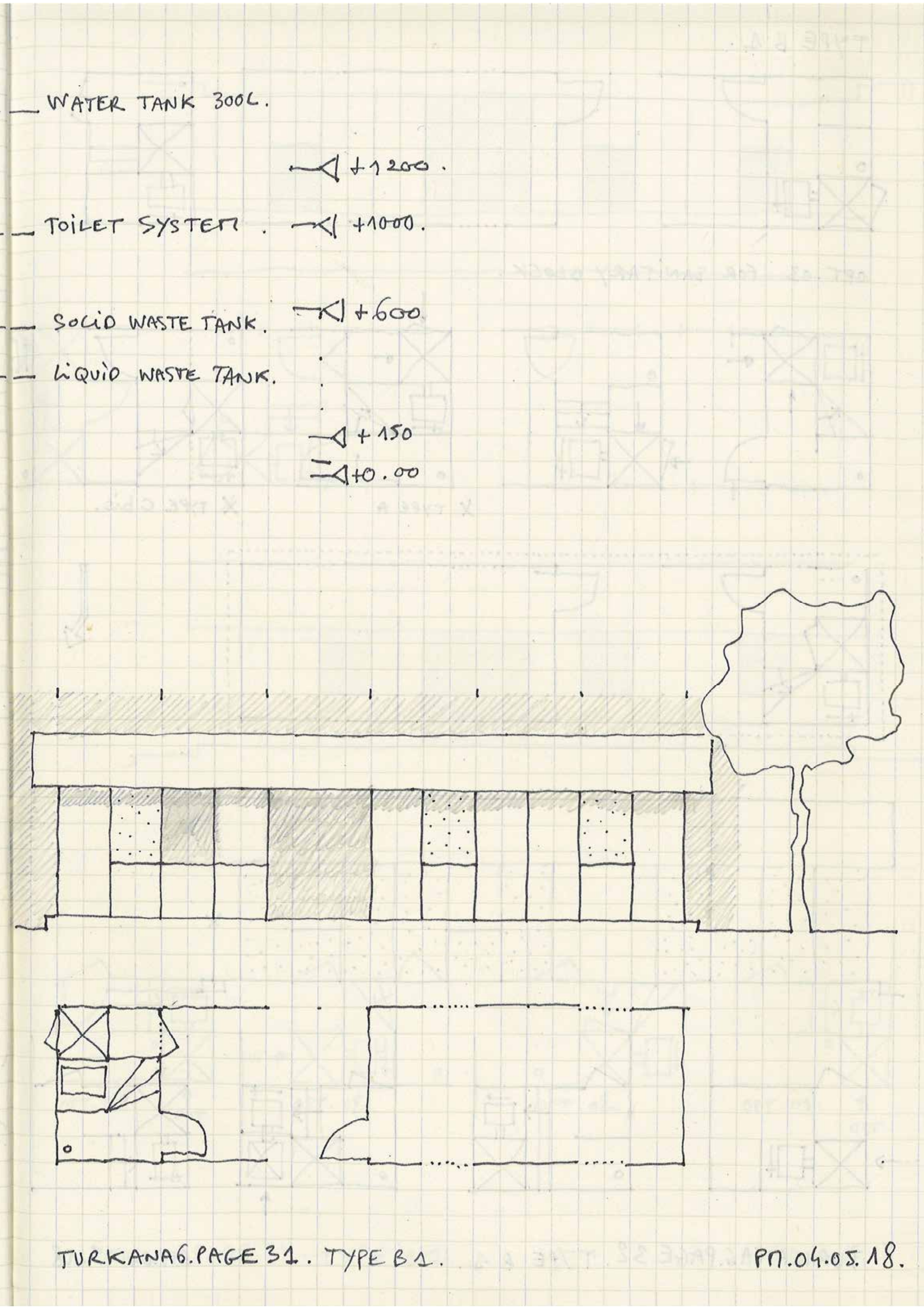
The Type D experience was very rewarding in terms of design, but also difficult due to harsh working conditions. The lack of resources was exacerbated by bad weather. The constraints and challenges were less inspiring than in previous missions. We faced several challenges that had major impacts on our design. My empathy towards people living in the region increased: the landscapes are breathtaking but the natural environment is tough.

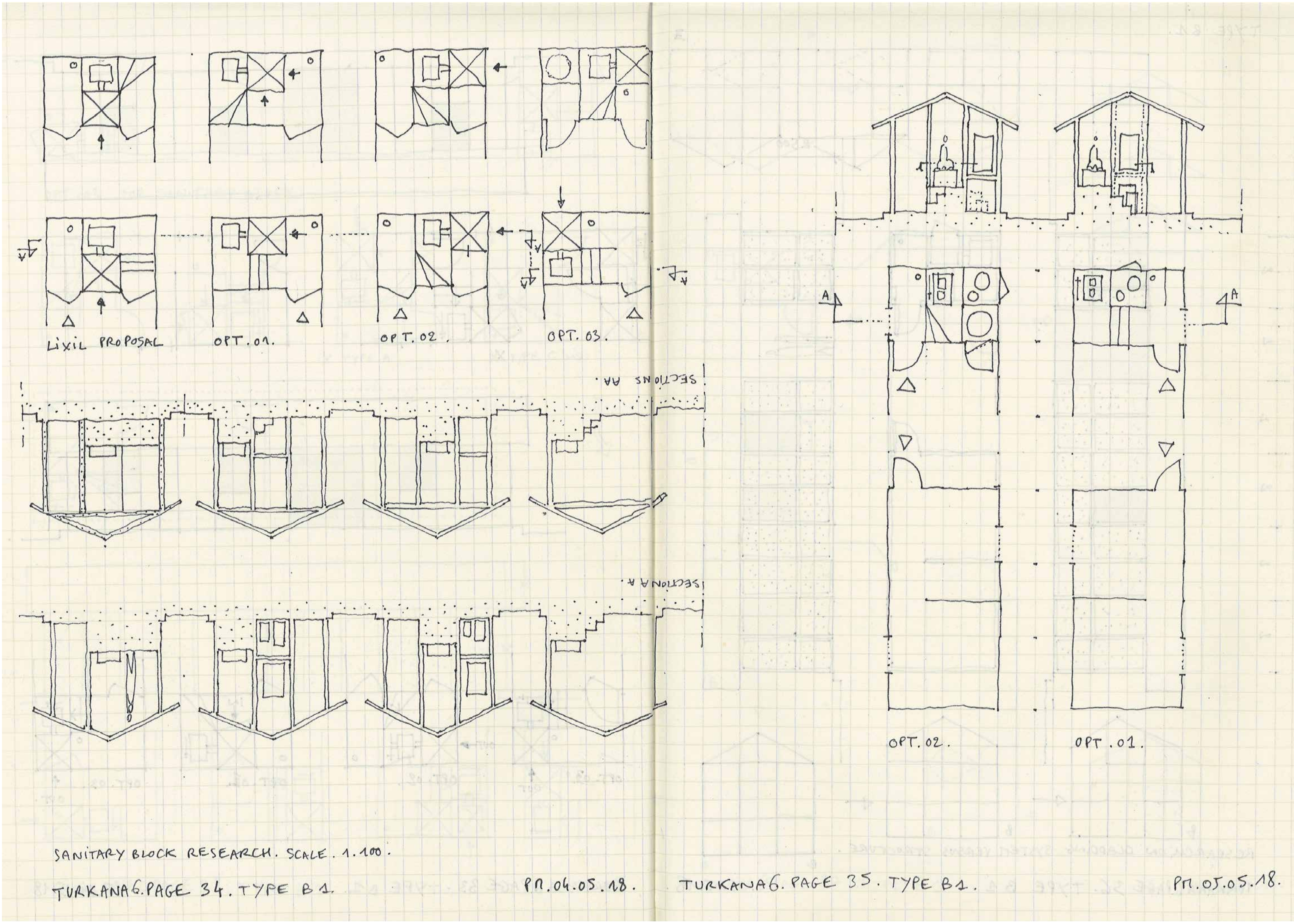
In terms of construction successes, we discovered the 'nail pivot' and the beautiful branch cladding that reminds me of traditional Turkana huts. The Type D House most closely reflects Turkana culture. However, one detail proved problematic for refugees, though not necessarily for Turkana people: it is easy to see through the gaps in the branches, making privacy difficult. Maybe the Turkana recognise a piece of themselves in the Branch House; or perhaps they have a different interpretation of privacy to that of refugees. When we entered Anne's house we passed through several layers. We opened a first gate in a large yard, then a second one in a private courtyard, and finally a small door to her bedroom. It appears that privacy is not created through opaque divisions and structures, but by several semi-transparent layers.

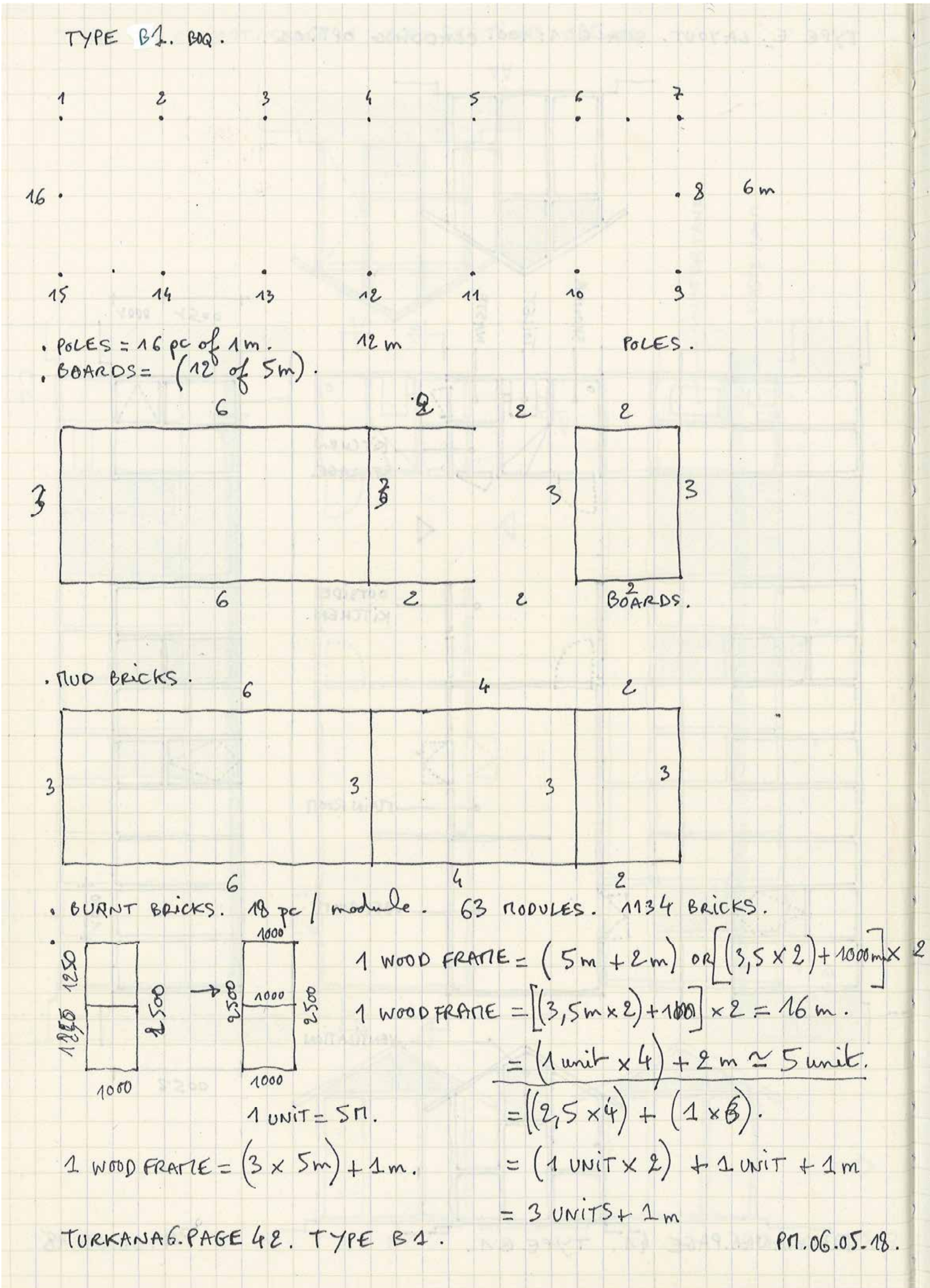
The Type D cladding is like one of these layers. Even if it may not be adopted as a single house due to its transparency and lack of privacy, it would be a perfect congregational point for resting or meeting friends. More importantly, it raises questions about the nuances of privacy and the understanding of what constitutes an intimate space. Does privacy exist behind the wall of the house, or behind the fence of the plot? Are there several levels of privacy which you can pass through, like in a typical Turkana pastoralist's household?

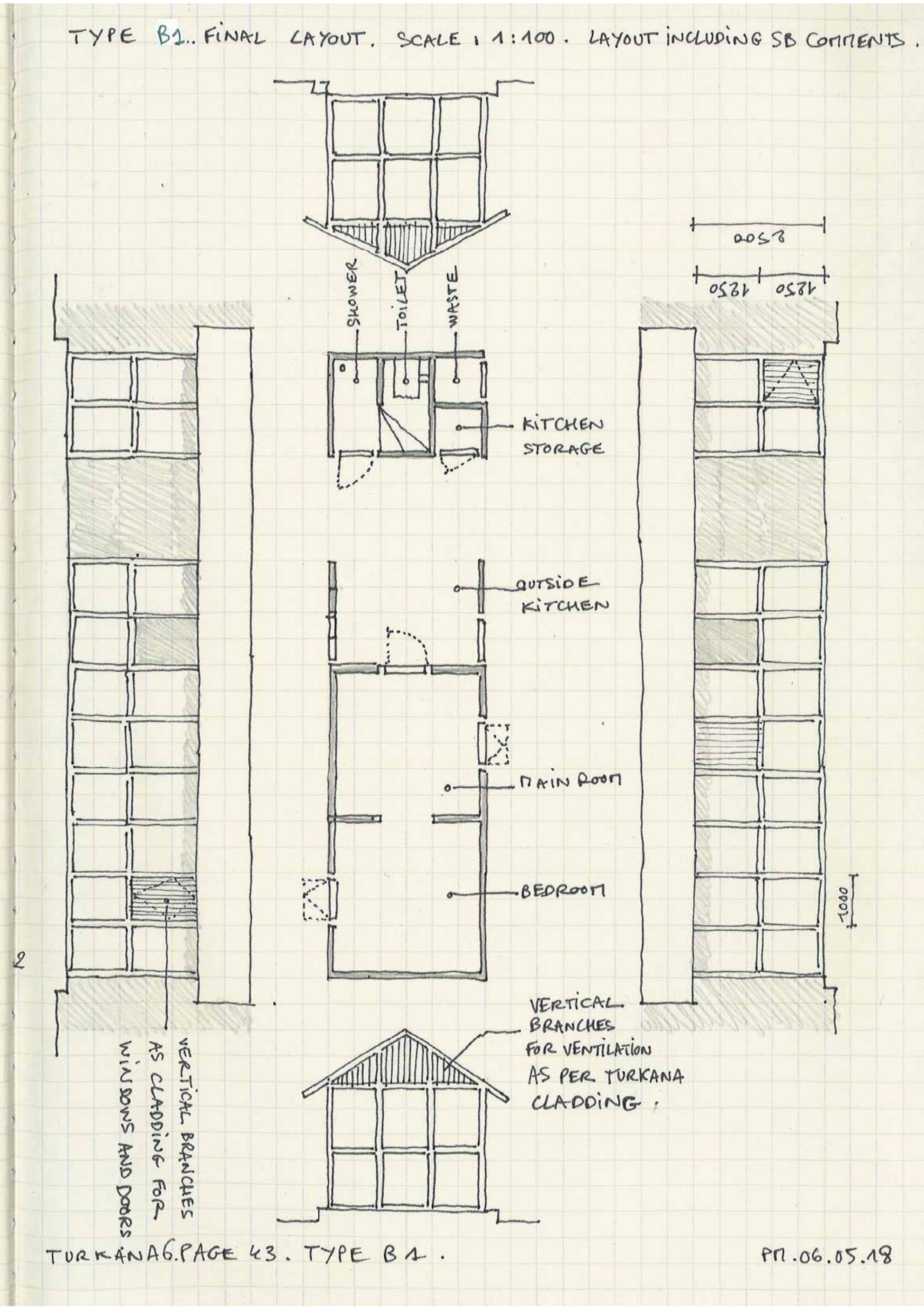
Following pages: extracts from Sketchbook n°6. House B1 research


TYPE B1. SANITARY BLOCK RESEARCH.
WATER TANK
TOILET
LIXIL
LIQUID
SOLID
WATER TANK 300L.
TOILET SYSTEM.
SOLID WASTE TANK.
LIQUID WASTE TANK.
+1200.
+1000.
+600
+150
+0.00
SOLID
LIQUID
LIXIL TOILET
KITCHEN.
STORAGE.
A
DETAIL OF TYPE A LAYOUT ON PAGE 26. SCALE: 1.20.
TURKANA6.PAGE 30. TYPE B1.
PM.04.05.18.


TURKANA6.PAGE 31. TYPE B1.
PM.04.05.18.


LIXIL PROPOSAL
OPT. 01.
OPT. 02.
OPT. 03.
SANITARY BLOCK RESEARCH. SCALE. 1.100.
TURKANA6. PAGE 34. TYPE B1.
PR.04.05.18.
A
A
OPT. 02.
OPT. 01.
TURKANA6. PAGE 35. TYPE B1.
PR.05.05.18.


TYPE B1. BOQ.
6m
12 m
POLES.
. POLES = 16 pc of 1m.
. BOARDS = (12 of 5m).
BOARDS.
. MUD BRICKS.
. BURNT BRICKS. 18 pc / module. 63 MODULES. 1134 BRICKS.
1 WOOD FRAME = (5m + 2m) OR [(3,5 x 2) + 1000m] x 2
1 WOOD FRAME = [(3,5m x 2) + 1000] x 2 = 16 m.
= (1 unit x 4) + 2 m ≃ 5 unit.
= ((2,5 x 4) + (1 x 3)).
= (1 UNIT x 2) + 1 UNIT + 1 m
= 3 UNITS + 1 m
1 UNIT = 5M.
1 WOOD FRAME = (3 x 5m) + 1 m.
TURKANA6.PAGE 42. TYPE B1.
PM.06.05.18.


TYPE B1.. FINAL LAYOUT. SCALE : 1:100. LAYOUT INCLUDING SB COMMENTS.
SHOWER
TOILET
WASTE
KITCHEN STORAGE
OUTSIDE KITCHEN
MAIN ROOM
BEDROOM
VERTICAL BRANCHES AS CLADDING FOR WINDOWS AND DOORS
VERTICAL BRANCHES FOR VENTILATION AS PER TURKANA CLADDING.
TURKANA6.PAGE 43. TYPE B1.
PM.06.05.18

From a Shelter to a House

Mission M11. May 2018

A Toilet for the House

Mid-April. UN-Habitat asks us to select one typology for a future pilot house that will incorporate a toilet unit from Lixil Corporation's Green Toilet System (see details page 212). Shigeru Ban's choice is Type B, the timber frame house with burnt bricks. In addition to toilets, the house should incorporate a water source for washing. Therefore, we need to design for the installation of a water tank under the roof, probably situated in a mezzanine level of the double storey house instead of a second level. The idea is to build timber frame modules with modules of squares (1 metre each), using three instead of two, to achieve the taller house from Type B. I draw some new assembly details for the taller timber frames.

April 19th. Shigeru Ban refuses the proposed idea. Though I have lowered the height to a mezzanine level, he believes it is a pilot too dangerous to mass produce if built by unskilled workers.

May 4th. I draw the Lixil system in detail to understand how it works and incorporate it into the design of the new pilot house.

May 6th. I prepare a layout for the next potential pilot. It incorporates a sanitary block separate from the main room. The roof covers both units, creating an enclosed but relatively open space between the units. This space can be defined as semi-private. The idea comes from my observation of our surroundings. Most of the refugees have large families. As per shelter cluster frameworks, the UN allocates one shelter for every five people – an average family size. They provide two shelters next to one another for larger families. Refugees usually link the two shelters with a tent-shaped roof to provide a common space for the family.

Fig. 77. Type D. Inside the shelter before the second layer of branches is applied

Fig. 78. Type D. A close-up view of the branches woven together

Fig. 79. Type D. Isaac applies the second layer of branches

Fig. 80. Type B1. Nailing the timber frames on the foundation boards

Fig. 81. Type B1. Sedar nails long horizontal sections at the top of the frames

In November last year, Jia Cong, from UN-Habitat Headquarters, in Nairobi, produced a report on UNHCR T-shelter transformations initiated by refugees in Kalobeyei New Settlement. One of her case study illustrates the interventions described above.
I am thinking about reducing the quantity of timber by removing the intermediate horizontal construction of the timber modules. Shigeru Ban advises me to keep this part and to locate the entrance door to the middle of the short façade for a stronger and more stable house. This leads to the design of the Type B1 House, using the same system as Type B but with a sanitary unit and a veranda. The drawings are now ready for construction.

Mid-May. I am back on site to introduce the new pilot house, Type B1, with the amenities recommended by UN-Habitat. The foundation is similar to the Type B House, which includes holes for Prosopis poles, and boards nailed on top of the poles.

Type D. A Second Layer of Branches

While we work on the foundations another team led by Isaac,[26] is adding a new cladding of branches on the Type D House to minimise the transparency of the shelter. It takes four full days to complete the work (Fig. 77, 78, and 79).
During this construction phase, we observe a lot of wood dust in the house, and tiny holes in the branches. Ekai, our 'Turkana boy'[27], explains that it is a type of beetle that eats the branches from inside. This is not considered an issue by locals, as their habitats are traditionally of temporary nature, but we will need to take this into account for our next pilot shelter construction which is looking to be more permanent.

Type B1. Timber Assembly Method

May 15th. Alas! The timber delivered for Type B1 is not termite-proof. We prepare a basin lined with tarpaulin, and dip the timber sections in an anti-termite treatment for a few hours. This explains this greenish colour of the wood in the pictures.

May 16th. We start producing the frames. When we assembled the Type B House the timber frames were mostly twisting, so we added an additional wood section on top of the modules to nail the trusses onto the walls. For Type B1, we decide to fabricate the frames ourselves, and to assemble the bottom and two sides of each timber module. We will add the long wood section at the very end to cover the frames, after nailing the timber frames onto the foundations. The idea is to reduce the quantity of wood used.

Fig. 82. Type B1. Timber truss assembly and bracing test

May 17th. We start nailing the timber frame modules onto the foundations (Fig. 80).

May 18th. We complete the installation of the modules in the morning. Sedar nails the first horizontal timber section on top of the frames (Fig. 81), while Gilbert creates the roof trusses. He saws a notch at the edge of the top trusses and the kingpost for an interlocking-joint. It will prevent the structure from collapsing, because the top trusses are sitting on the kingpost. I prepare a sketch of the house to quantify the number of bricks needed to fill the wood frame modules.

May 19th. The seven trusses are completed and pre-positioned on the timber walls (Fig. 82). Driving back to the UN compound, we are ready to cross the Tarach River, the main river next to Kakuma. This time the usually dry river bed is flooded. Lucas explains that each time it is raining in the Uganda mountains near the border, a large flow of water is expected a few hours later in Tarach River, even without rain in Kakuma.We have to cross now, before the water level becomes too high, and the current too strong. It would be adventurous to cross in half an hour, even with a four-wheel drive vehicle.

May 20th. We nail the trusses onto the timber modules, and Gilbert links them together with the top and bottom purlins (Fig. 83).

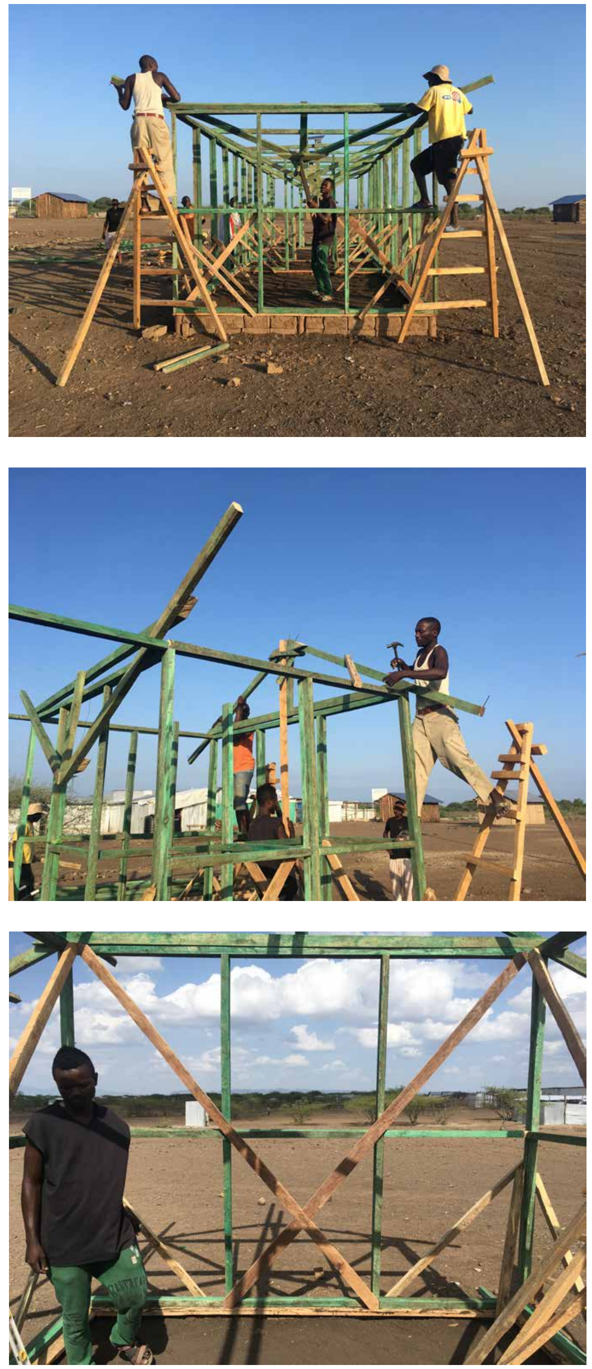


Fig. 83. Type B1. Timber trusses assembly and bracing test

Fig. 84. Type B1. Corrugated iron roofing and branch cladding on doors

Fig. 85. Type B1. Bruno and Sedar nail branches onto the door frames

As I want to reduce the quantity of wood used for the bracing of the wood panels, I sketch an axonometric view with the positioning of the minimum bracing required for the stability of the structure. Of course, I modify the principle on site, but my aim to reduce the quantity of wood is achieved.

May 21st. Gilbert and Punda[28] install the tarpaulin, while Sedar tries to improve the 'nail pivot' detail.

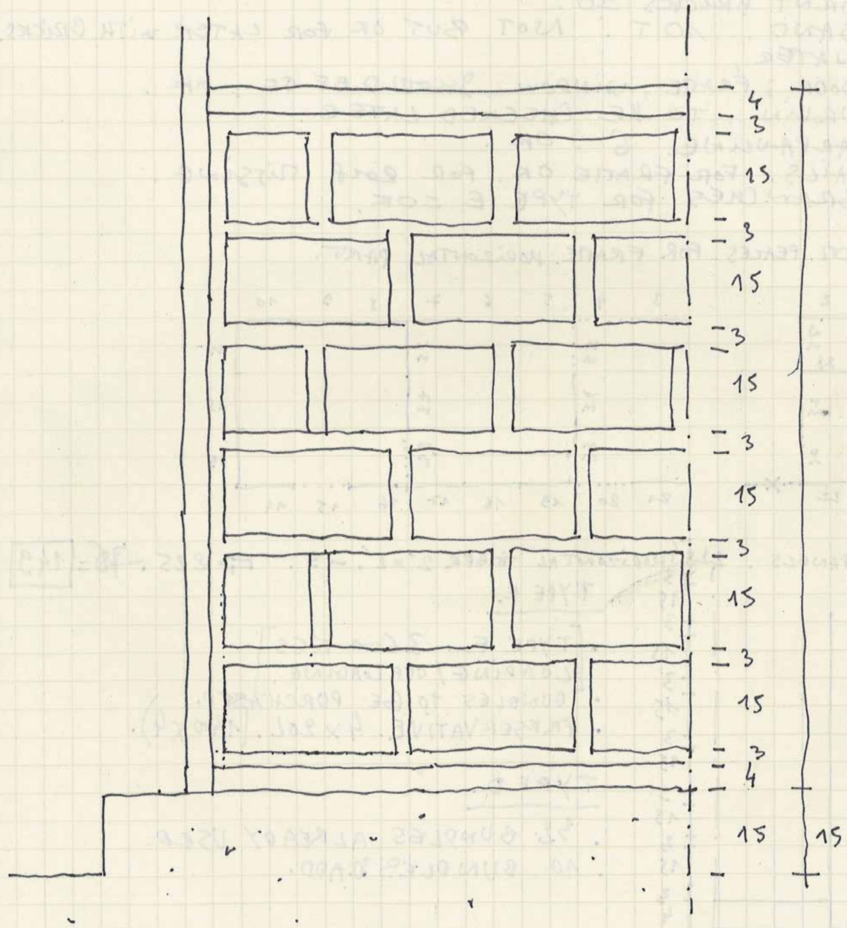
May 22nd, 23rd. While Gilbert and Punda pursue the work on the roof with the nailing of the corrugated sheets, Sedar, Isaac, Bruno and Ekai assemble the branches on the future doors (Fig. 84 and 85). Despite showers of rain, we manage to install all of them with the famous 'nail pivot' detail.

Lessons Learned. A New Plan

This month we designed a new shelter plan that includes a sanitary unit and a veranda. We are now moving from a simple shelter to a real house. Even though the Lixil Green Toilet System uses dry toilets to prevent strong odours, from my conversations with some refugees, I came to understand that it is necessary to keep the structure separate from the bedrooms, however they clearly do not want toilets located far from the house. The current community toilets are dangerous for women at night because they need to leave the house to go to the bathroom, so I design separate toilets under the same roof, for better access, greater comfort and security. The research produced a good result: an outside living room for cooking, socialising, resting, or even a place to tell stories in the evening - outside living room between a large sleeping room and the bathroom unit. A shaded, open resting space is common in Turkana County.
The unexpected but useful lesson learned from this mission was identifying and addressing the voracity of the local beetles that are eating the branches of our Type D shelter!

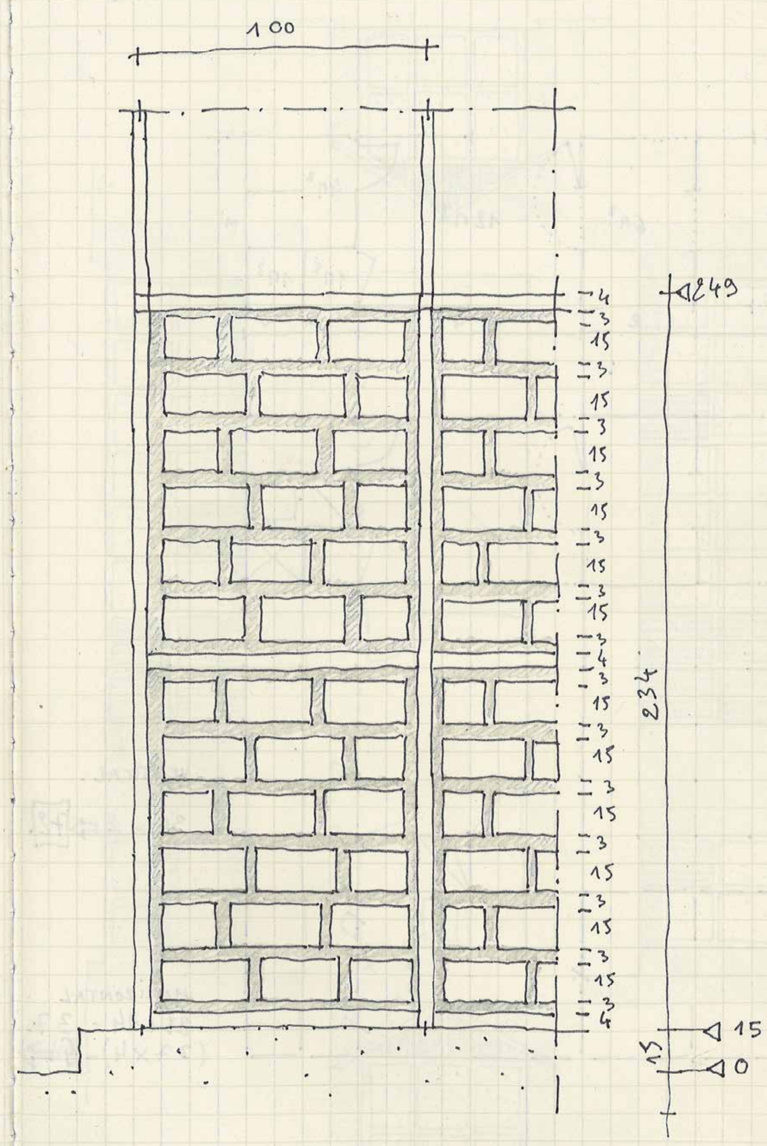
Following pages: extracts from Sketchbook n°7. B1 adjustments

TYPE B1. WOOD FRAME SCALE . 1.10.



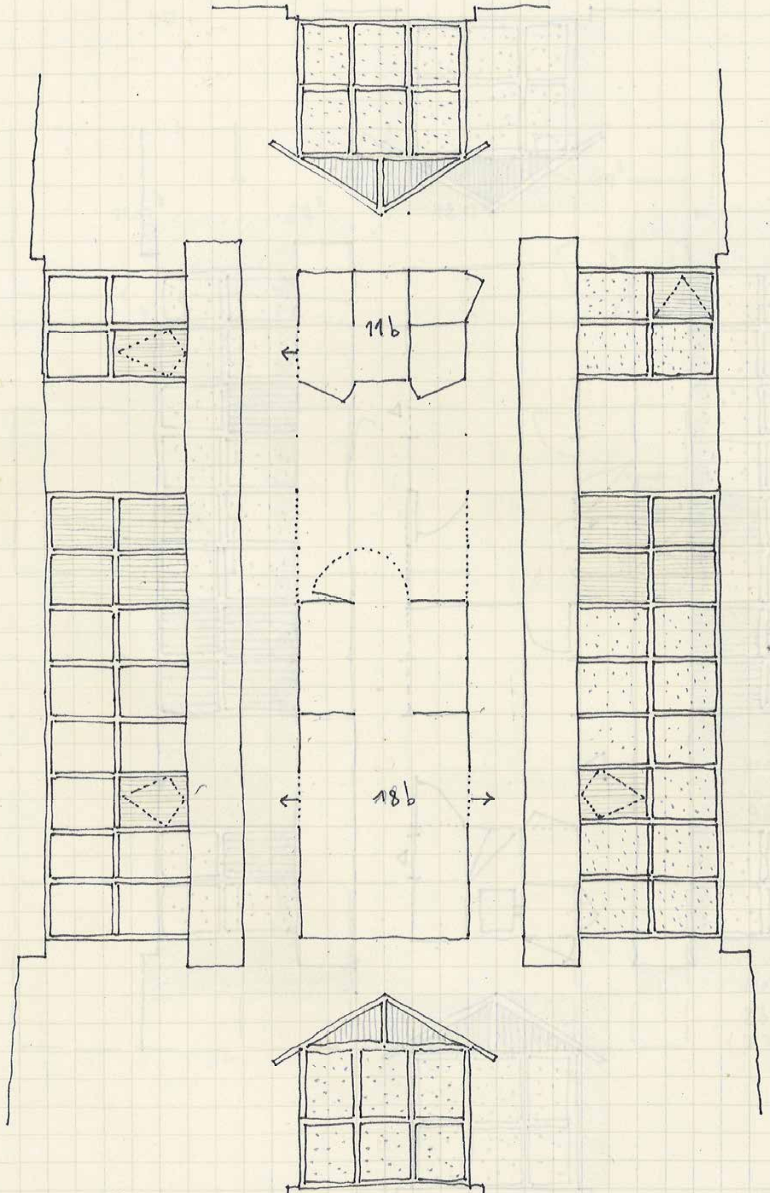
TURKANA7. PAGE 08 . TYPE B1. PM. 16.05.18

TYPE B1 . WOOD FRAME . 1.20 .



TURKANA7. PAGE 09. TYPE B1. PM. 16.05.18.

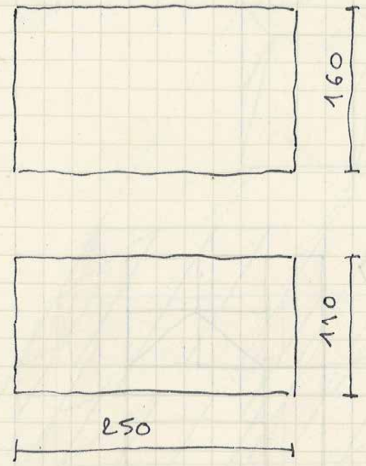
TYPE B1. LAYOUT FOR CONSTRUCTION.



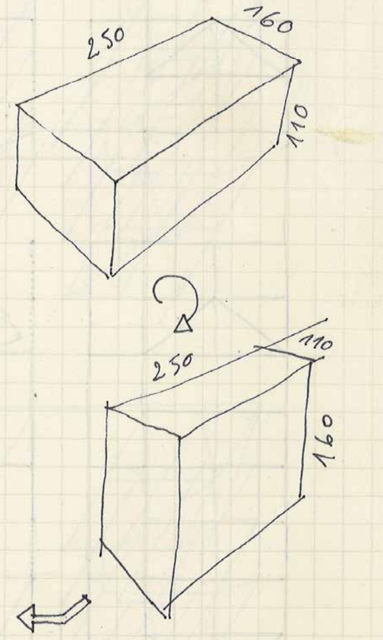
TURKANA7.PAGE 12. TYPE B1. PM.18.05.18

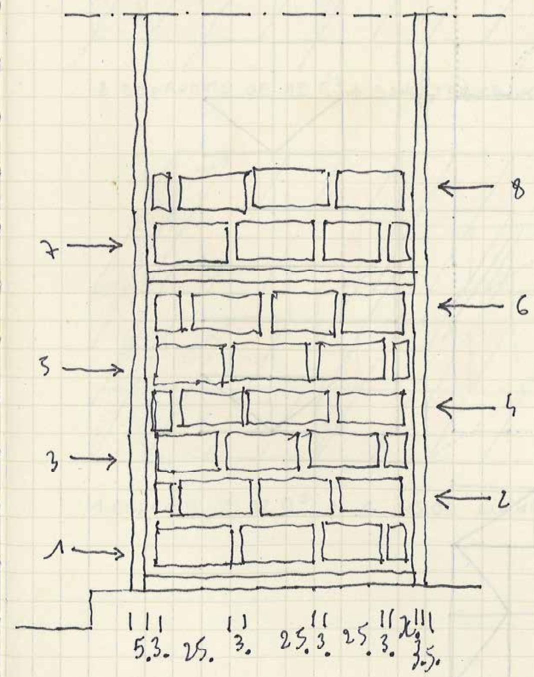
TYPE B1. BRICK LAYOUT.

KALOBEYEI TOWN BRICKS DIMENSION.



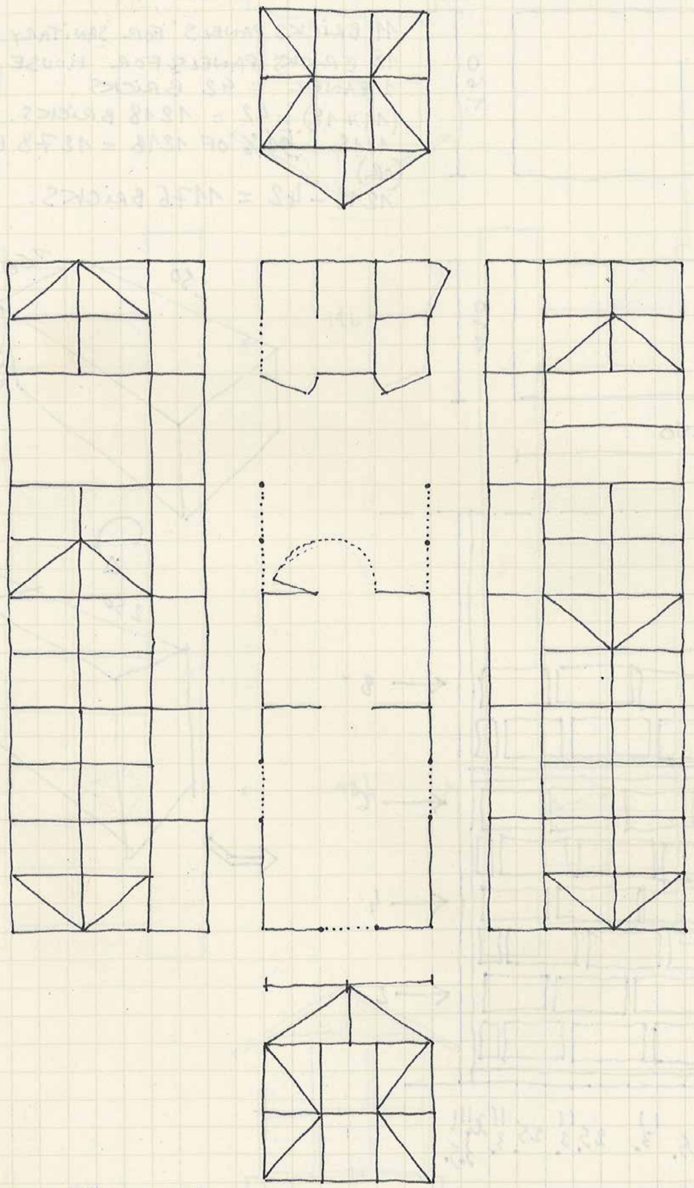
11 BRICKS PANELS FOR SANITARY BLOCK.
18 BRICKS PANELS FOR HOUSE.
1 PANEL = 42 BRICKS.
(11+18) x 42 = 1218 BRICKS.
1218 + 5 % OF 1218 = 1278 BRICKS.
(OR)
1218 - 42 = 1176 BRICKS.





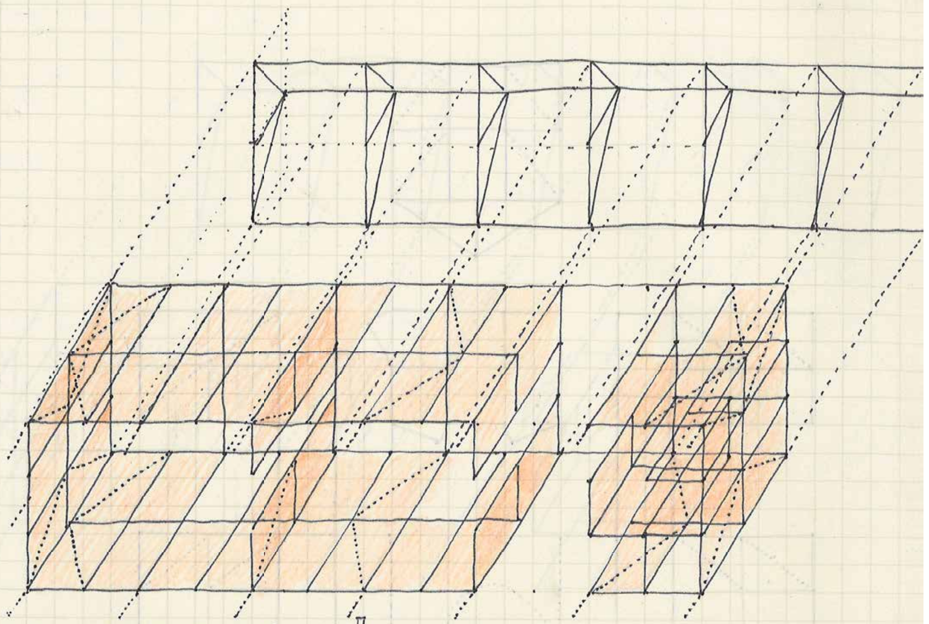
TURKANA7.PAGE 13. TYPE B1. PM. 18.05.18

TYPE B1. BRACING SYSTEM.

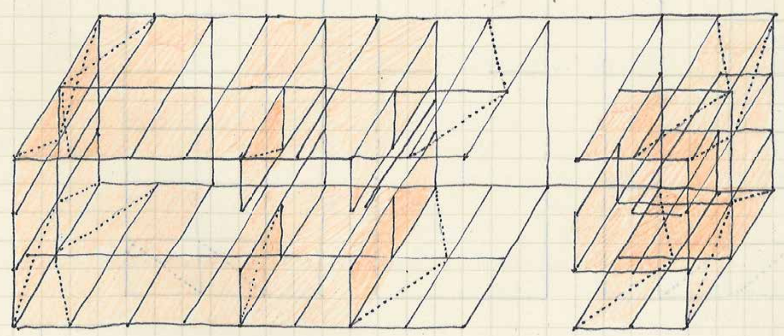


TURKANA 7. PAGE 14. TYPE B1. PM.19.05.18

TYPE B1. STRUCTURE. DIAGRAM.



2 BEDROOMS OF 12 M² + SANITARY BLOCK.



1 BEDROOM OF 12 M² + 1 INSIDE LIVINGROOM + 1 OUTSIDE KITCHEN + SANITARY.

TURKANA 7. PAGE 15. TYPE B1. PM.19.05.18

Burnt Bricks and Shigeru Ban's Visit

Mission M12. July 2018

Renovating the Floors

The rainy season has damaged the outer edges of our pilot shelters. Since we must now reconstruct one of the pilot houses with branches, we take the opportunity to renovate the fourth pilot.
July 2nd. Nyaluak and Nyaoum are on site. Punda places the raw mud bricks that define the edge of the shelter. They prepare the mixture and apply the first layer on Types B and D (Fig. 86, 87, and 88).
The next day, we pick up some soil from the Laguna in the morning, then Nyaluak and Nyaoum apply the finishing layer.

Type B1. Burnt Brick Production Issues

In mid-May, we met the burnt brick-makers and they assured us that they could have the bricks ready for delivery by mid-June. Now it is mid-June, but not one brick has been produced.
Once again, I observe the lack of organisation on site. As the rainy season is persisting, the Kalobeyei people who were supposed to produce the bricks for Type B1 could not manage to do so. The main issue is that they do not have a shelter to store and protect the mud bricks. We are now condemned to wait until the end of the rainy season before there is any hope of getting any bricks delivered. There is not much else that we can do for now.

Placing raw mud bricks using twine as a guide

The bricks are doubed with a mixture of local soil + water

Mixture of laguna soil + local soil with water applied above the first layer of mud

Fig. 86. Type D. Daubing the edges with soil (the same process was used for Types A, B and C)

Fig. 87. Type D. Nyaluak and Nyaoum apply the soil mixture to bricks placed by Punda

Fig. 88. Type D. Nyaluak and Nyaoum apply the finishing layer

The windscreen cladding of the veranda

Sedar places twine to align burnt bricks

Bricks chosen by Ekai, wet by Punda and laid by Sedar

Fig. 89. Type B1. Cladding with Sedar, Punda and Ekai. Assembling Prosopis branches and burnt bricks

Fig. 90. Type B1. The North-West facade

Fig. 91. Type B1. The North-East facade. A work in process with bracing still visible from outside

Fig. 92. Shigeru Ban and the site team on the veranda of House B1

July 2nd. The bricks are finally delivered. Omari and I nail the frames to ensure that the mortar sticks to the wood. Punda prepares the mortar and wets the bricks to make them adhesive, and Gilbert put the first bricks into the timber frames.

July 3rd and 4th. The team works on the cladding.

July 5th. Sedar takes over Gilbert's cladding work, and we start building the stairs to the toilets. We first define the edges of the steps with burnt bricks and fill them with soil. Then we cover the soil with small stones we find lying around. Lastly, Gilbert covers the stones with a fine layer of mortar to ensure that the floor is waterproof.

July 6th. The last day on site, half of the house is constructed using bricks. In addition to the doors and the windows, I decide to construct a wind screen made of branches on both sides of the veranda to provide some intimacy in the outdoor living space, and good ventilation. This idea is inspired by a practical application of our experience of the Branch House (Fig. 89, 90, and 91).
A few days later, Gilbert and his team will complete the cladding, and Yu Yamakami from Lixil Corporation will install the toilets.

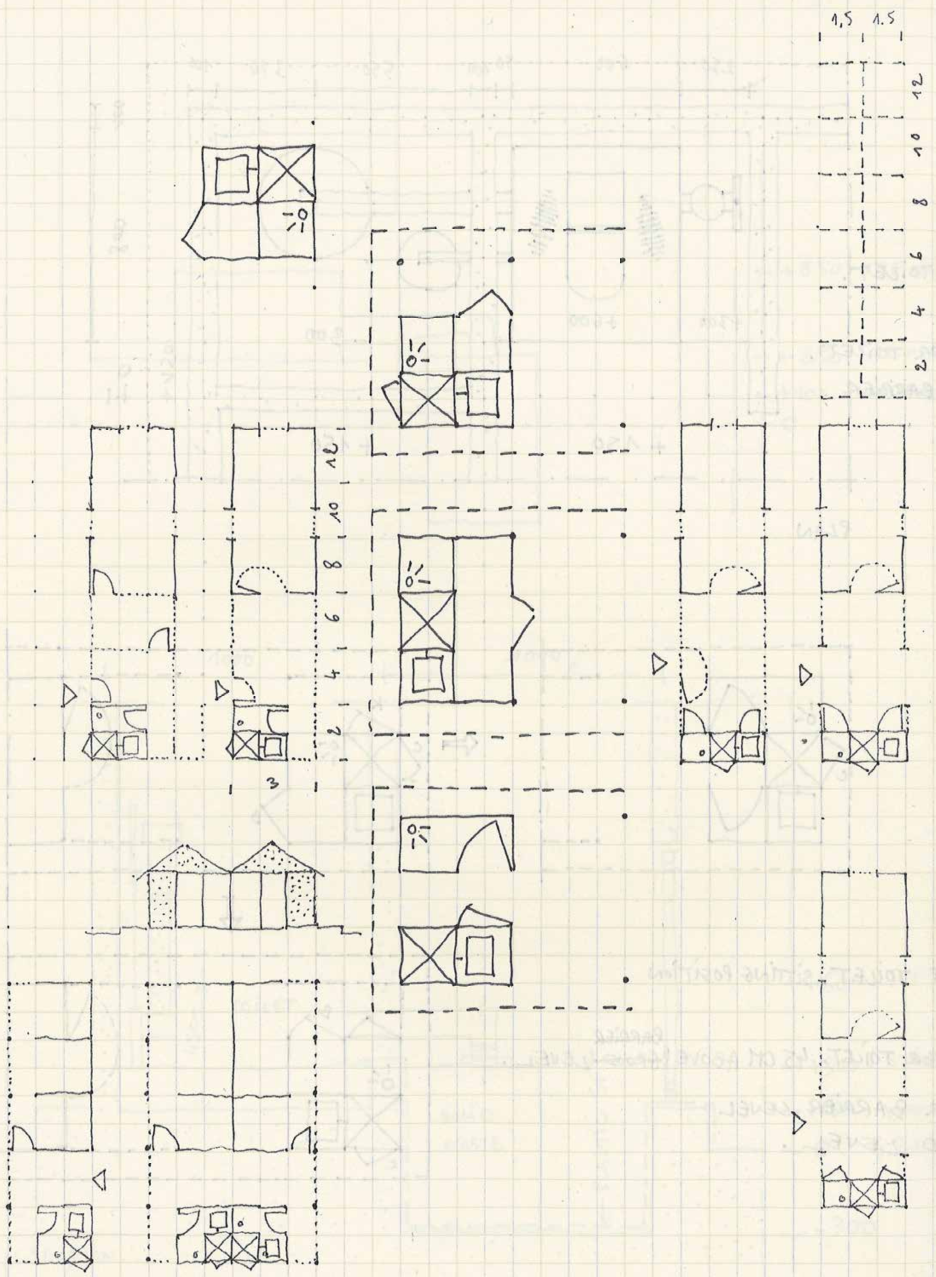
Shigeru Ban's Visit

July 24th. Shigeru Ban arrives in Kalobeyei to inspect the work that has been done over the year (Fig. 92). It may seem like slow progress with only five houses completed, but it has been a long journey from the exploration of materials, techniques, and possibilities to larger-scale production. We found the model we were looking for in the timber frame structure filled with burnt bricks, and managed to move from an 18m² pilot shelter to a 36m² house with a main room, its own toilets and a large veranda for resting and eating in a covered and well-ventilated space.

Lessons Learned. Burnt Bricks for Kalobeyei

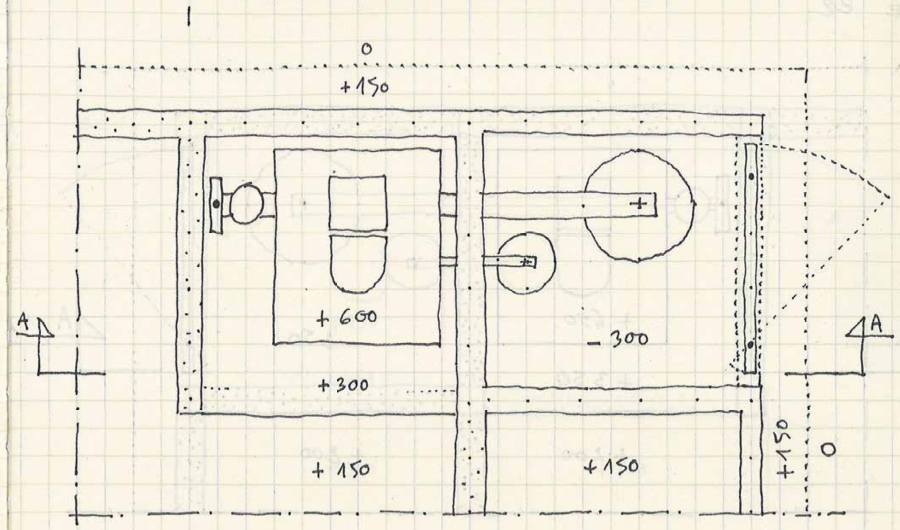
From a positive perspective, even though we lost a lot of time waiting for the burnt bricks to be delivered, we provided some jobs and eventually a long term business opportunity for the Kalobeyei Town community. To help this venture progress, we need to order more burnt bricks to push local manufacturers to better organise their production. This could significantly contribute to the economic development of the region. With its new plan, the last pilot house in Kalobeyei incorporates the flexibility of Type B system and gives us a blueprint for production on a larger scale.

Following pages: extracts from Sketchbook n°8. Research for House B2

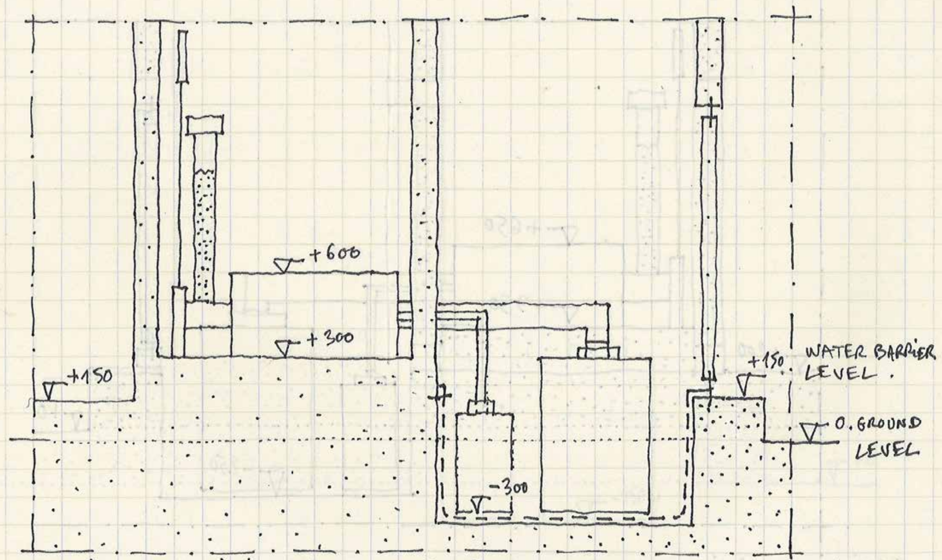


TURKANA 8. PAGE 06. TYPE B2.

PM.01.08.18



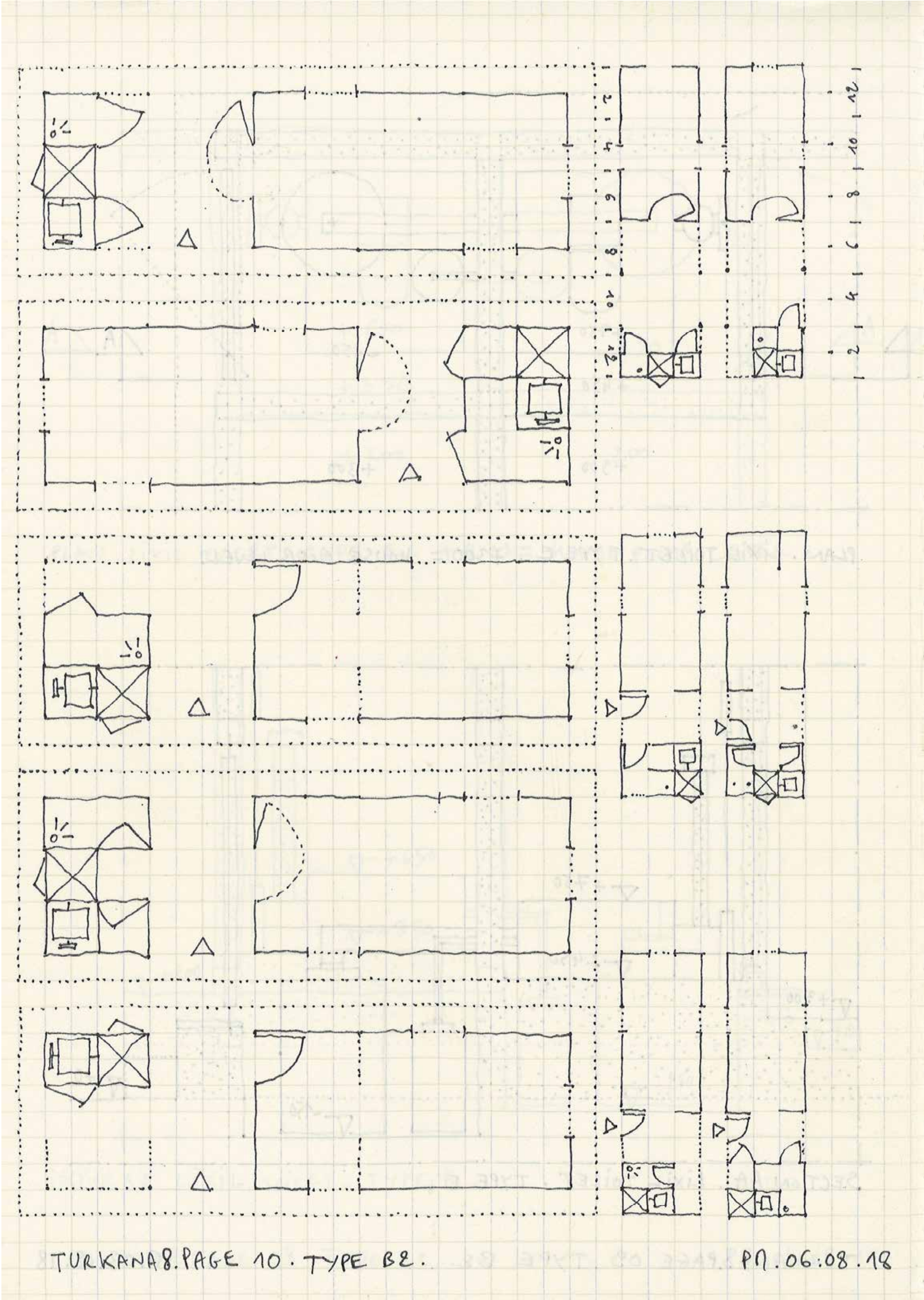
PLAN. LIXIL TOILET SYSTEM. TYPE E.
+ 150 = HOUSE FLOOR LEVER.

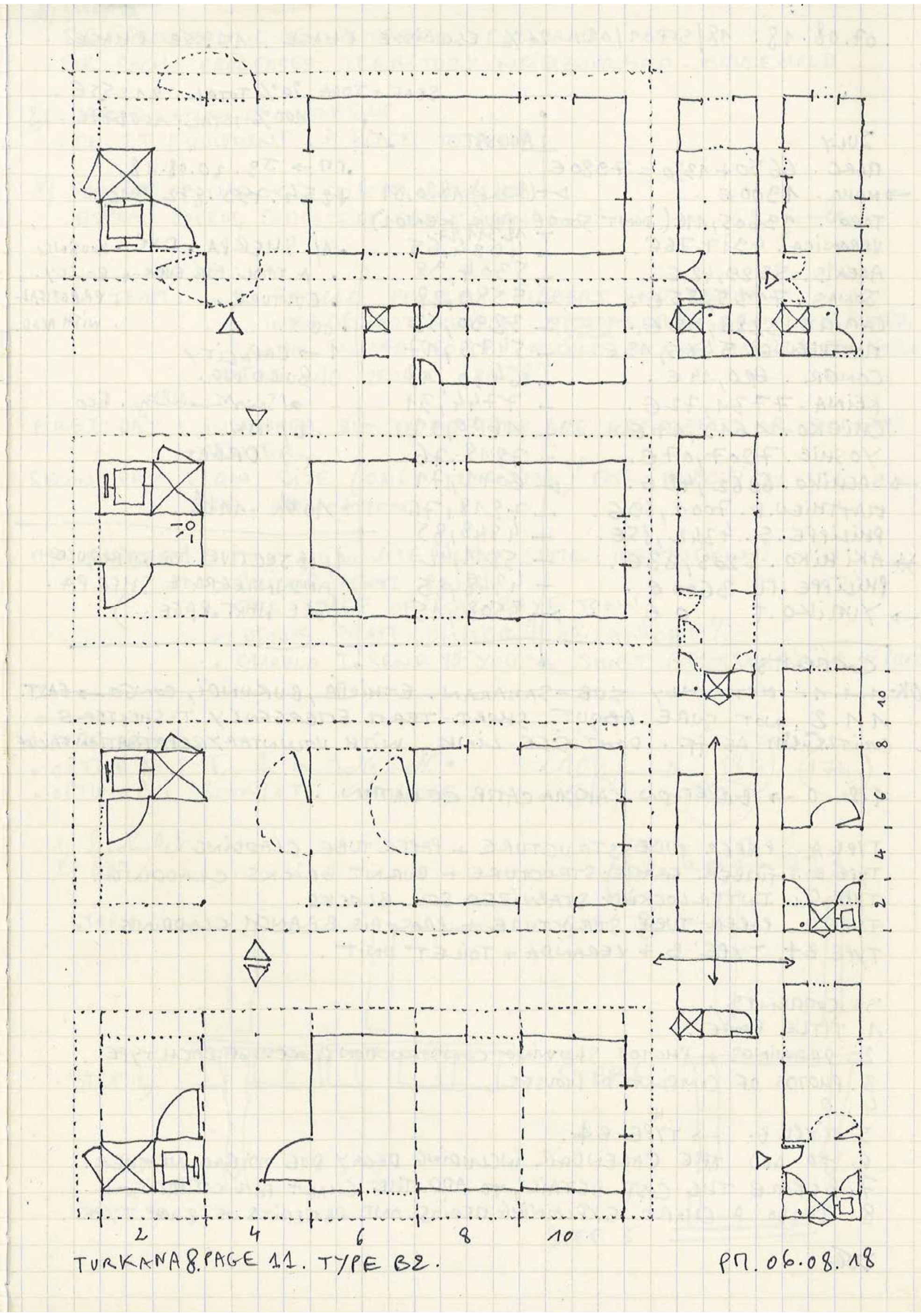


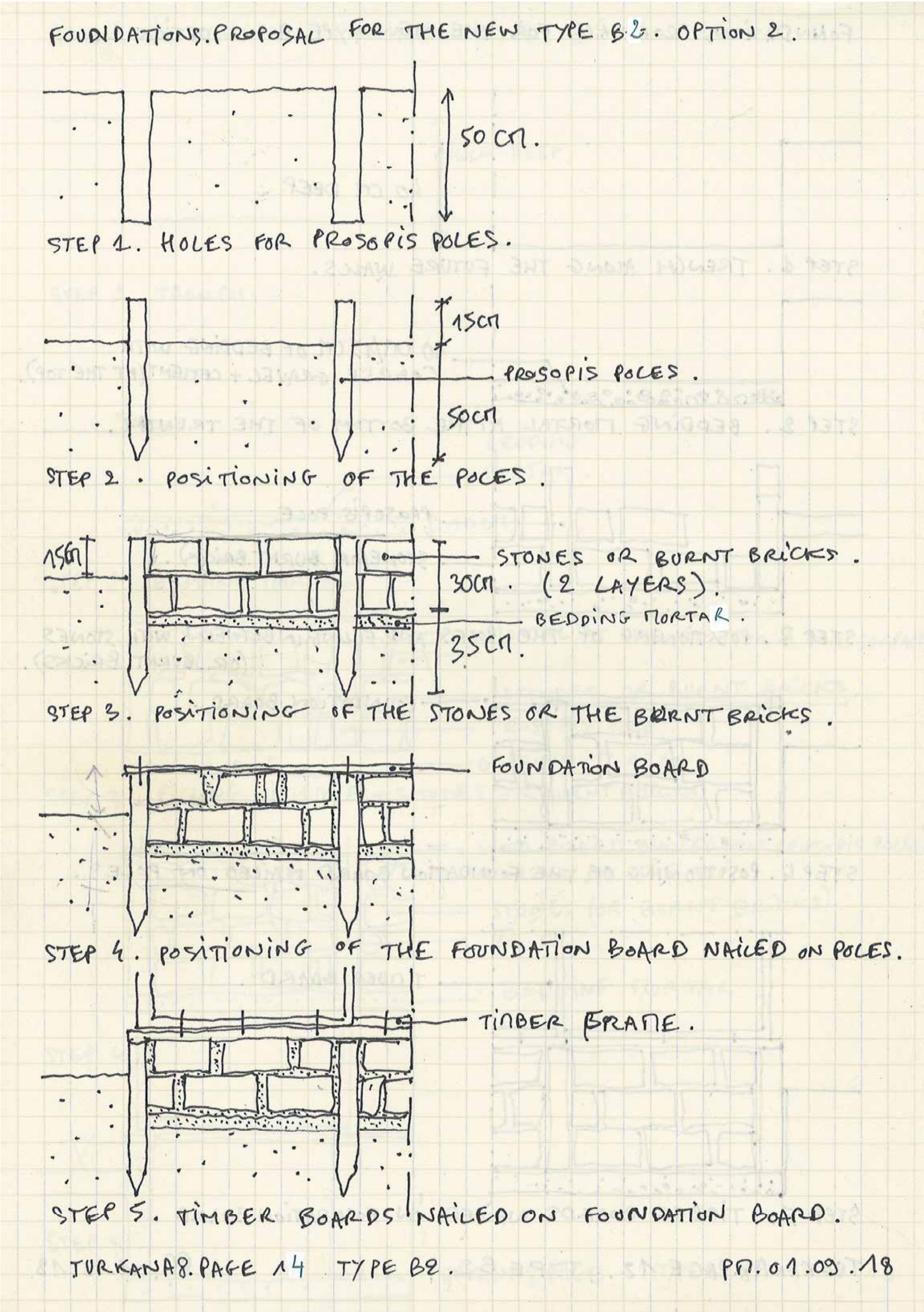
SECTION AA. LIXIL SYSTEM. TYPE E.

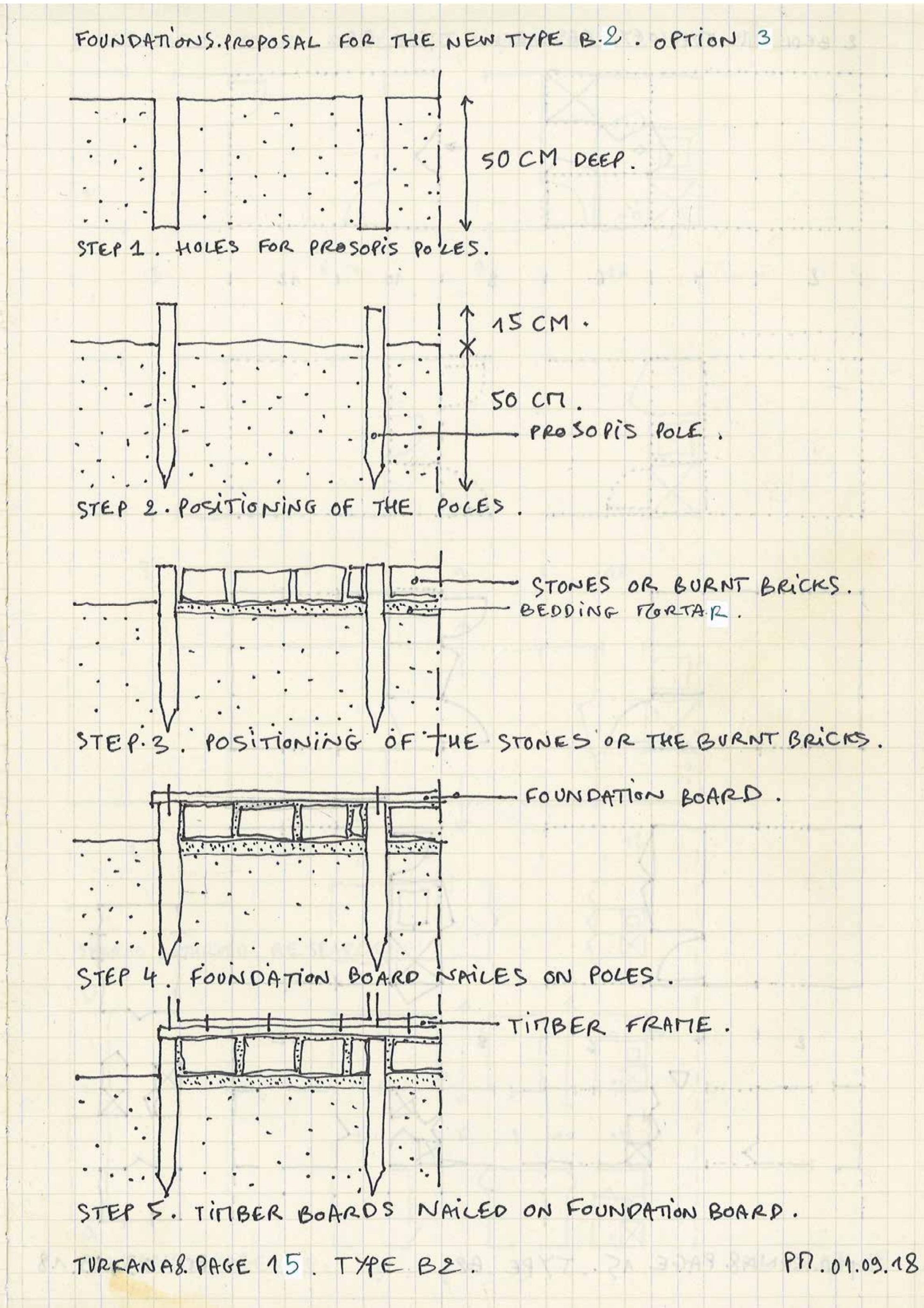
TURKANA 8. PAGE 07. TYPE B2

PM.01.08.18


TURKANA 8. PAGE 10. TYPE B2.
PП. 06.08.18


2
4
6
8
10
TURKANA 8. PAGE 11. TYPE B2.
PП. 06.08.18


FOUNDATIONS. PROPOSAL FOR THE NEW TYPE B2. OPTION 2.
50 CM.
STEP 1. HOLES FOR PROSOPIS POLES.
15CM
PROSOPIS POLES.
50CM
STEP 2. POSITIONING OF THE POLES.
15CM
STONES OR BURNT BRICKS.
30CM. (2 LAYERS).
BEDDING MORTAR.
35CM.
STEP 3. POSITIONING OF THE STONES OR THE BURNT BRICKS.
FOUNDATION BOARD
STEP 4. POSITIONING OF THE FOUNDATION BOARD NAILED ON POLES.
TIMBER FRAME.
STEP 5. TIMBER BOARDS NAILED ON FOUNDATION BOARD.
TURKANA18. PAGE 14 TYPE B2.
PM. 01.09.18


FOUNDATIONS. PROPOSAL FOR THE NEW TYPE B.2. OPTION 3
50 CM DEEP.
STEP 1. HOLES FOR PROSOPIS POLES.
15 CM.
50 CM.
PROSOPIS POLE.
STEP 2. POSITIONING OF THE POLES.
STONES OR BURNT BRICKS.
BEDDING MORTAR.
STEP 3. POSITIONING OF THE STONES OR THE BURNT BRICKS.
FOUNDATION BOARD.
STEP 4. FOUNDATION BOARD NAILES ON POLES.
TIMBER FRAME.
STEP 5. TIMBER BOARDS NAILED ON FOUNDATION BOARD.
TURKANA18. PAGE 15. TYPE B2.
PM. 01.09.18

A Frame for Experimentation

Mission M13. Sept. Oct. 2018

In March 2019, UN-Habitat will construct eight more shelters. These will not be built for research purposes, but will be allocated to refugees and host community members. We still need to improve some details before scaling up production, especially for the assembly of the timber structure. Therefore, I propose to Shigeru Ban and UN-Habitat that we build another 36m² pilot house before moving to the next step: the future House B2.

A More Durable Water Barrier

September 1st. I arrive on site and inspect the B1 pilot house. The outer edge that we completed a month ago is already in bad shape due to recent rain.
That evening, while looking for an alternative, I come up with a hybrid option to prevent further damage: using poles to anchor the house and creating a water barrier of stones.

September 2nd. Ekai starts to dig the trenches for the foundations while Gilbert manufactures the first timber frames. The plan of the house crystallises in the process.

September 3rd. Gilbert positions the Prosopis poles while Ekai and Isaac are preparing the mortar. Gilbert then applies the mortar bedding with a home-made tool – a piece of board nailed to a timber section. The board is the width of the trench and he uses it to level the mortar which the stones will sit upon.

Fig. 93. Type B2. Drawing the plan with trenches

Fig. 94. Type B2. Passing Somali women looking at boards which indicate rooms in the future house

A Model from the Field

On the same day, while discussing with the team, I come to understand that most locals are happy with the type B1 design, but they feel it is missing one component. After a quick survey of the immediate surroundings, I understand that we need to add a separate room to create privacy for parents. It is a fact that most African families are large, and it would be unwise not to consider this in our design.
As we have not yet begun the foundations for the next typology, Gilbert and I decide to take the opportunity to build a two room house in this second 36m² pilot. Early the next morning I sketch some options to brainstorm together with the team, and we decide to build a shelter with two 12m² rooms, a bathroom attached to one of them, and a small covered outside living space in between. We literally draw the layout on the ground (Fig. 93). Ekai digs the trenches and Gilbert, with Isaac's help, places the stones in the trenches.

September 3rd. We nail the boards onto the poles in preparation for mounting the timber frames. The foundations are almost completed (Fig. 94).

Fig. 95. Using House B1 as a model for House B2 frames

A Stronger Timber Frame System

September 4th. After manufacturing one frame, I notice the potential struggle we will face should we build the frames one by one, due to the poor quality of the wood. I decide to prepare a new methodology for the assembly of the timber frames in the new plan. This time, we are going to build the walls in one go, using half-lap joints. This involves joining two planks of timber of equal thickness, crossed in either in a "T", a "+" or "x" shape. Each piece of wood is thinned by half thickness at the joint, so that when assembled the two pieces appear to be on the same plane.
As we do not have a 4x2 inch timber section, we first nail 2 pieces of 2x2 inches to create the section that we are looking for. House B1 is used as a template (Fig. 95).

Then the methodology is as follows (Fig. 96):
1. Nail the top and bottom sections to the vertical ones
2. Create a channel of 2x2 inches in the middle of the vertical sections
3. Interlock a 2x2 horizontal section in the channel
4. Nail 2x2 pieces to the horizontal section to complete the panel

Fig. 96. Type B2. Sedar nails a horizontal section (see step 3 of methodology)

Fig. 97. Type B2. Assembly of panels on foundation boards

Fig. 98. Type B2. A passing herd of goats remind us that we are on pastoralist land

Gilbert, Ekai and Isaac are working on the foundations. Punda treats the timber, and I help Sedar manufacture the frames using our new method. After two days, all the walls are ready for assembly. The panels are straight and structurally sound, and we have saved some time.

Assembly of Panels

September 6th. We test the assembly of four panels without using nails.

September 7th. We nail the panels together on the foundation boards. This method significantly reduces the time needed for construction, while maintaining the strength of the house. Some goats pass by, serving as a reminder that we are in a pastoralist territory (Fig. 97 and 98).

Cladding with Stones

October 8th. I am back on site for the cladding phase.
Bruno and Isaac are working on the doors and the windows. The 'roof windows' are already installed. The metal sheet has been chosen for the windows as it is the

Fig. 99. Type B2. Cladding with local stones

Fig. 100. Quarry near Pelekech with shaped stones to the right and waste on the left

Fig. 101. Type B2. Shaping stones with manual tools

Fig. 102. Type B2. The completed house, from the South-West (top) and North-West (bottom)

cheapest we can get in Turkana, and we need to lower the price per unit for the next ten houses.

We discover that the stones which have been delivered are not the best quality. Punda selects the best ones, Gilbert shapes them and Bruno assembles them into the timber frames (Fig. 99).

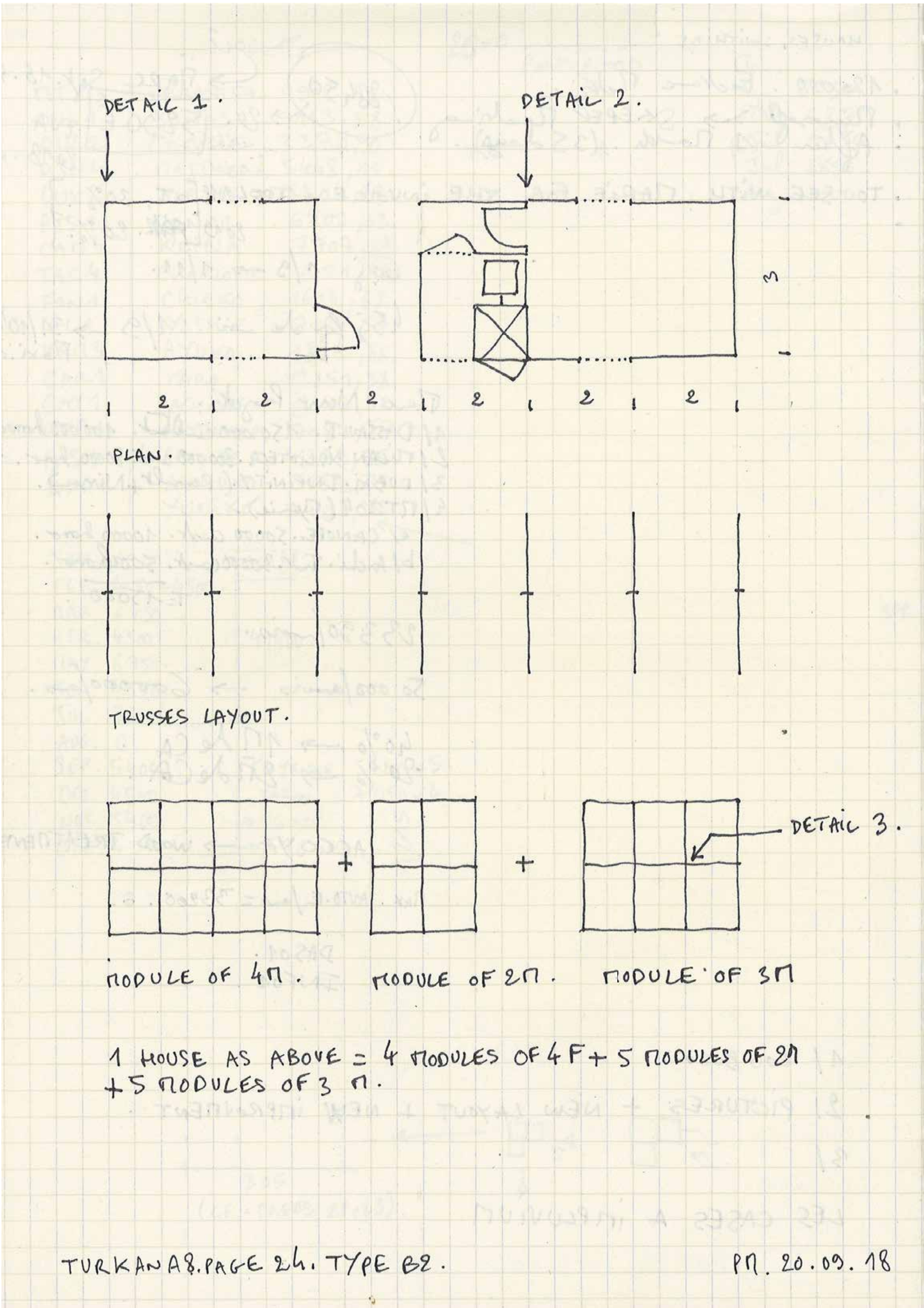
October 9th. Staff from Peace Winds Japan take me and Yuka to the quarry, as I want to learn more about the stones. When we arrive in Pelekech, my first impression is that the process of quarrying the stones produces a lot of wasted material. About twice the amount of stone in a single block is required to produce each one (Fig. 100). My second impression is that the work is extremely arduous: every stone is shaped with hand tools, using no machines. On the flipside, we realize that the stone masons have the skills to shape the stones if we pay a higher price (Fig. 101). Ultimately, this visit confirms that burnt bricks are the best option for our timber frame structures.

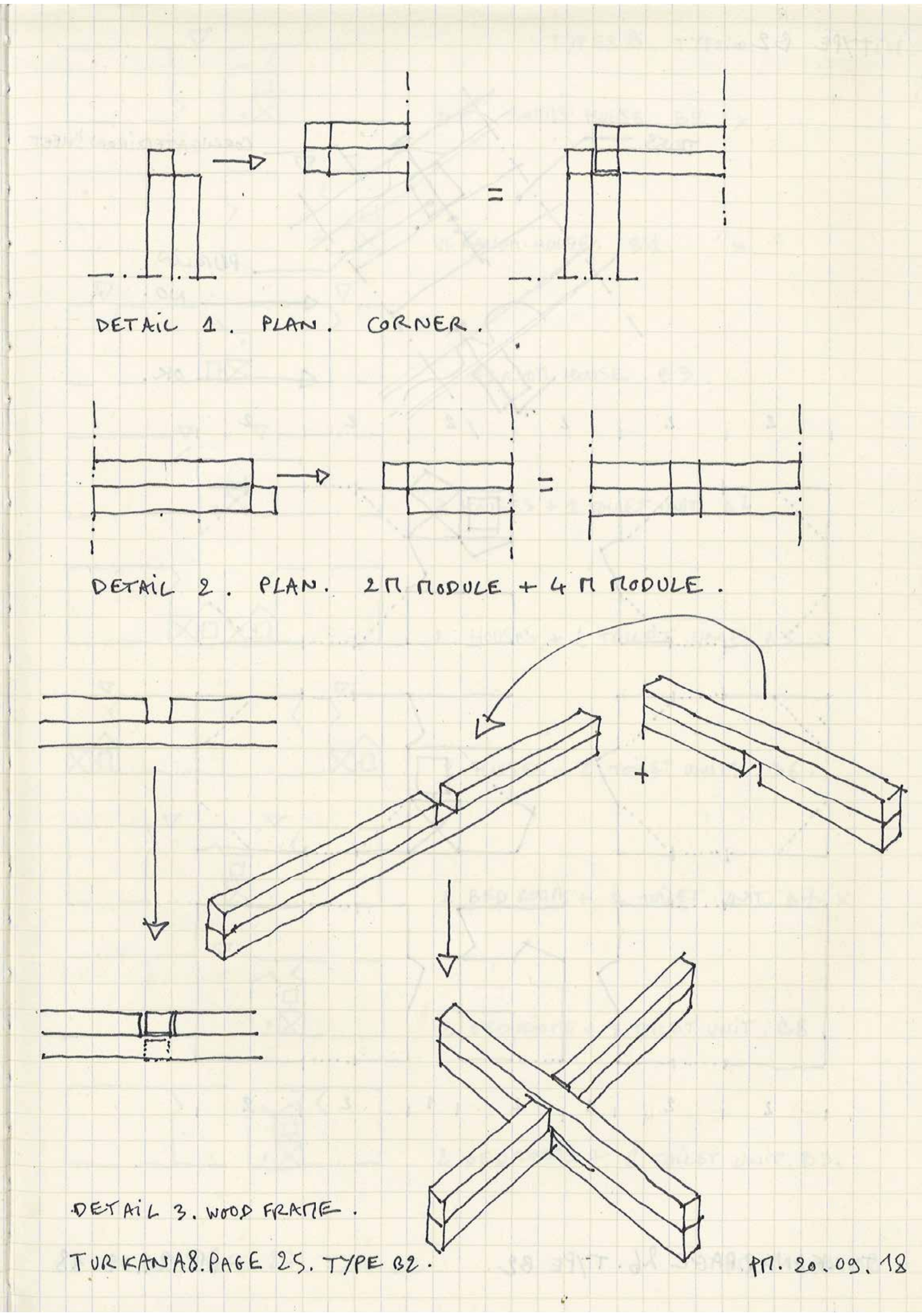
October 10th. The evening before my departure for Nairobi, the stone cladding has not reached the bottom of the house.
10 days later, Gilbert and his team will finally complete the cladding (Fig. 102).
The process of shaping the stones before the cladding work takes too long. Furthermore, even if the timber frame can support the weight of the stones, they look out of scale compared to the thickness of the wood structure. Though everyone in the team has worked hard to fit the stones into the squares, for now I consider this experiment a failure.

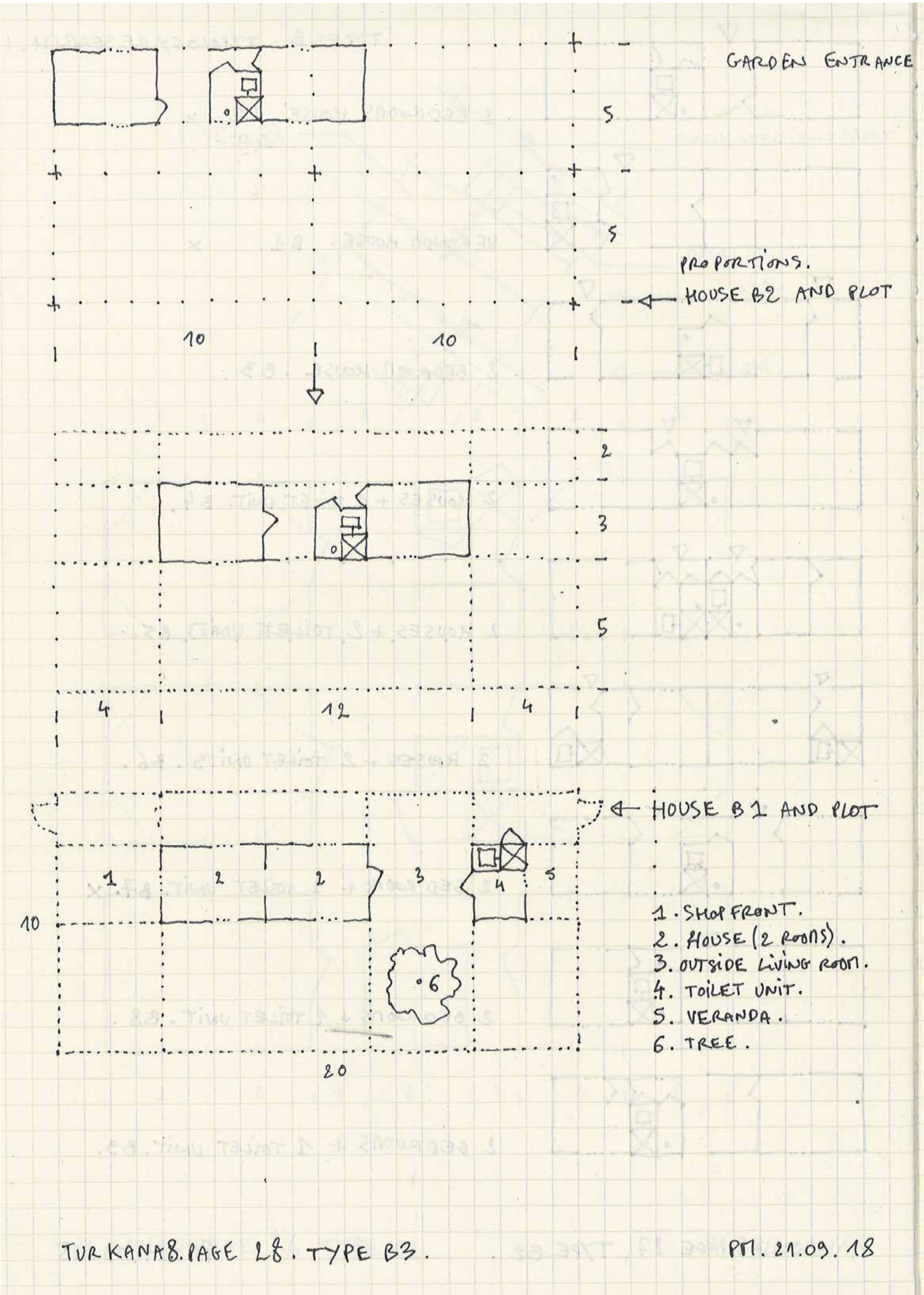
Lessons Learned. The Manual Begins to Take Shape

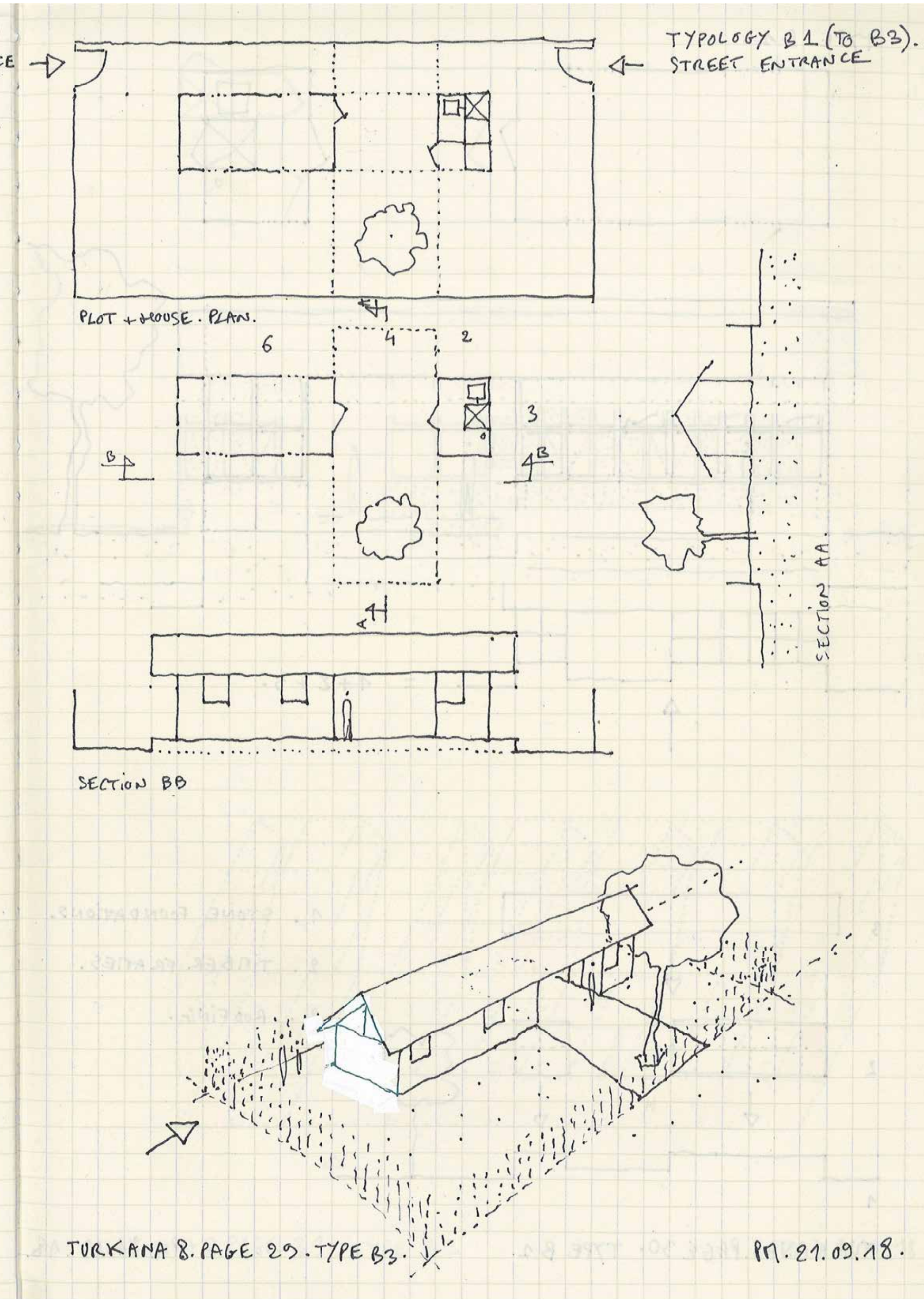
The stones are not in the right proportion for the pilot house. They are too big and heavy, and not properly shaped. From a technical perspective, it was worth testing the use of stones. However, the stones available in Turkana are not suitable for use within the timber frame structures. On the other hand, this test has pushed us to find a stronger system for building the timber structures, and it gave us a chance to test a new plan which resonates more with East African culture. These lessons will later lead me to create a building manual which lays out all the steps and details to construct a refined, two-room house.

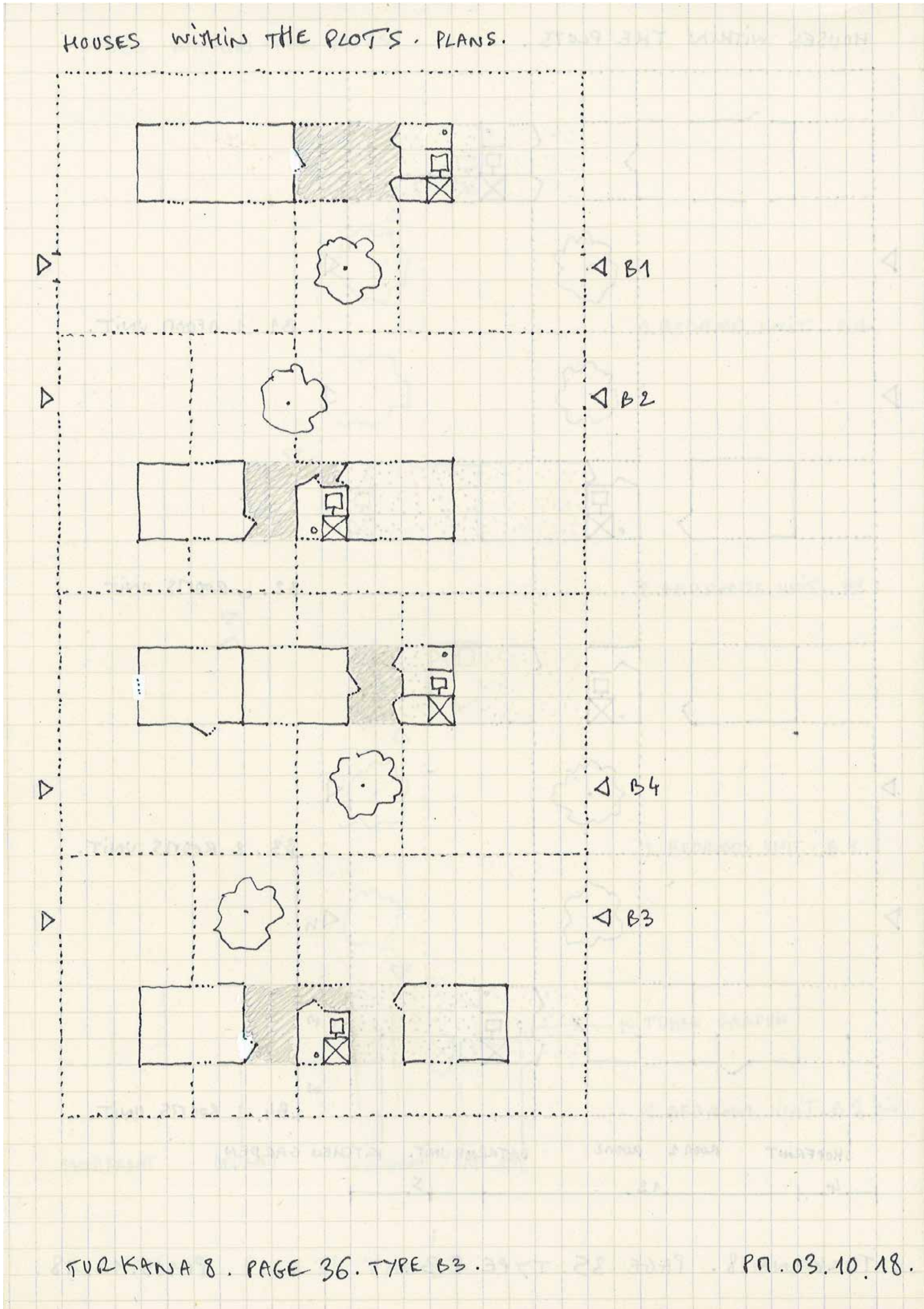
Following pages: extracts from Sketchbooks n°8, 9, 10. The B2 experience informs the B3 construction process

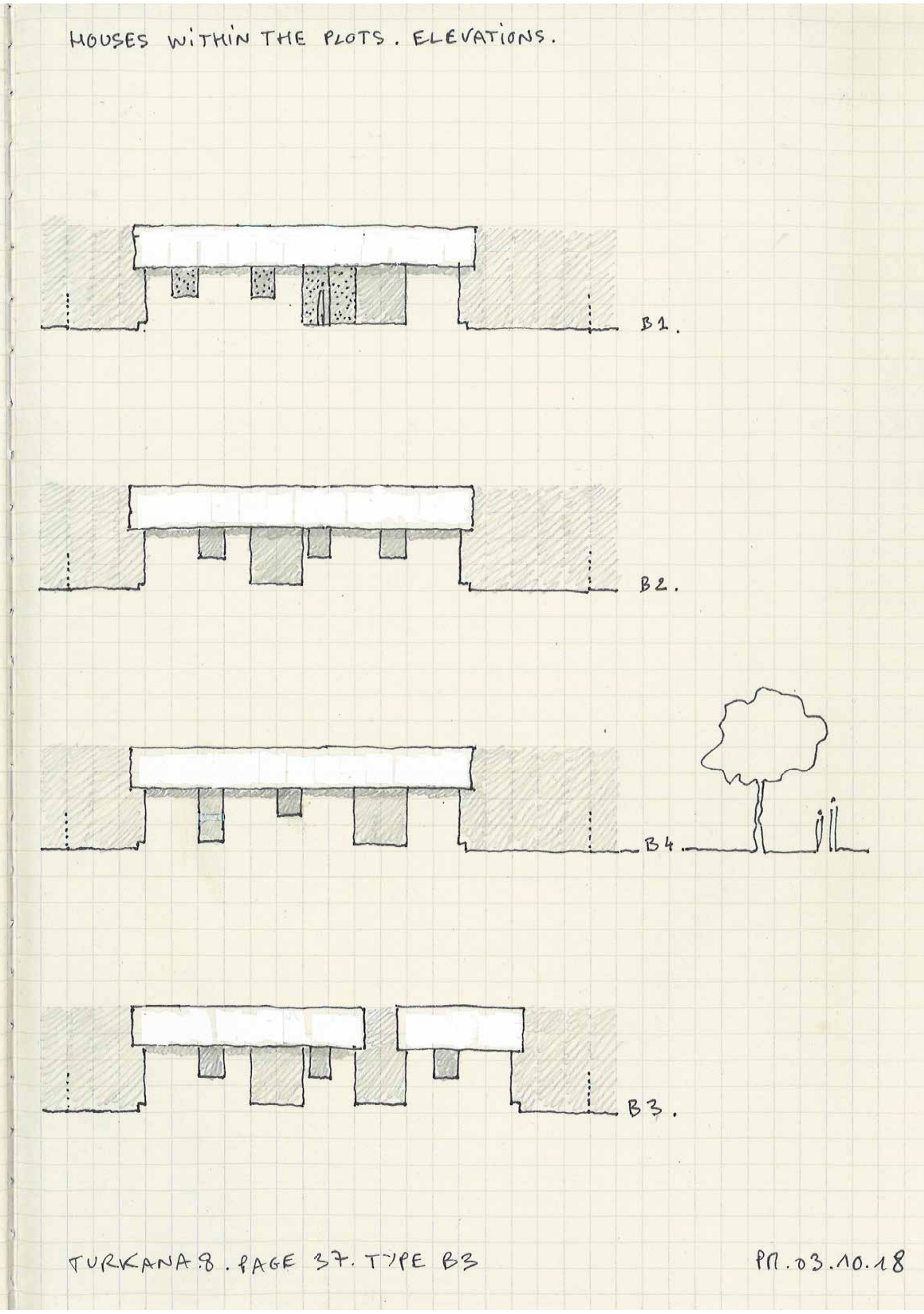

DETAIL 1.
DETAIL 2.
3
2 2 2 2 2 2
PLAN.
TRUSSES LAYOUT.
DETAIL 3.
MODULE OF 4Π. MODULE OF 2Π. MODULE OF 3Π
1 HOUSE AS ABOVE = 4 MODULES OF 4F + 5 MODULES OF 2Π
+ 5 MODULES OF 3 Π.
TURKANA8. PAGE 24. TYPE B2.
PΠ. 20.09.18

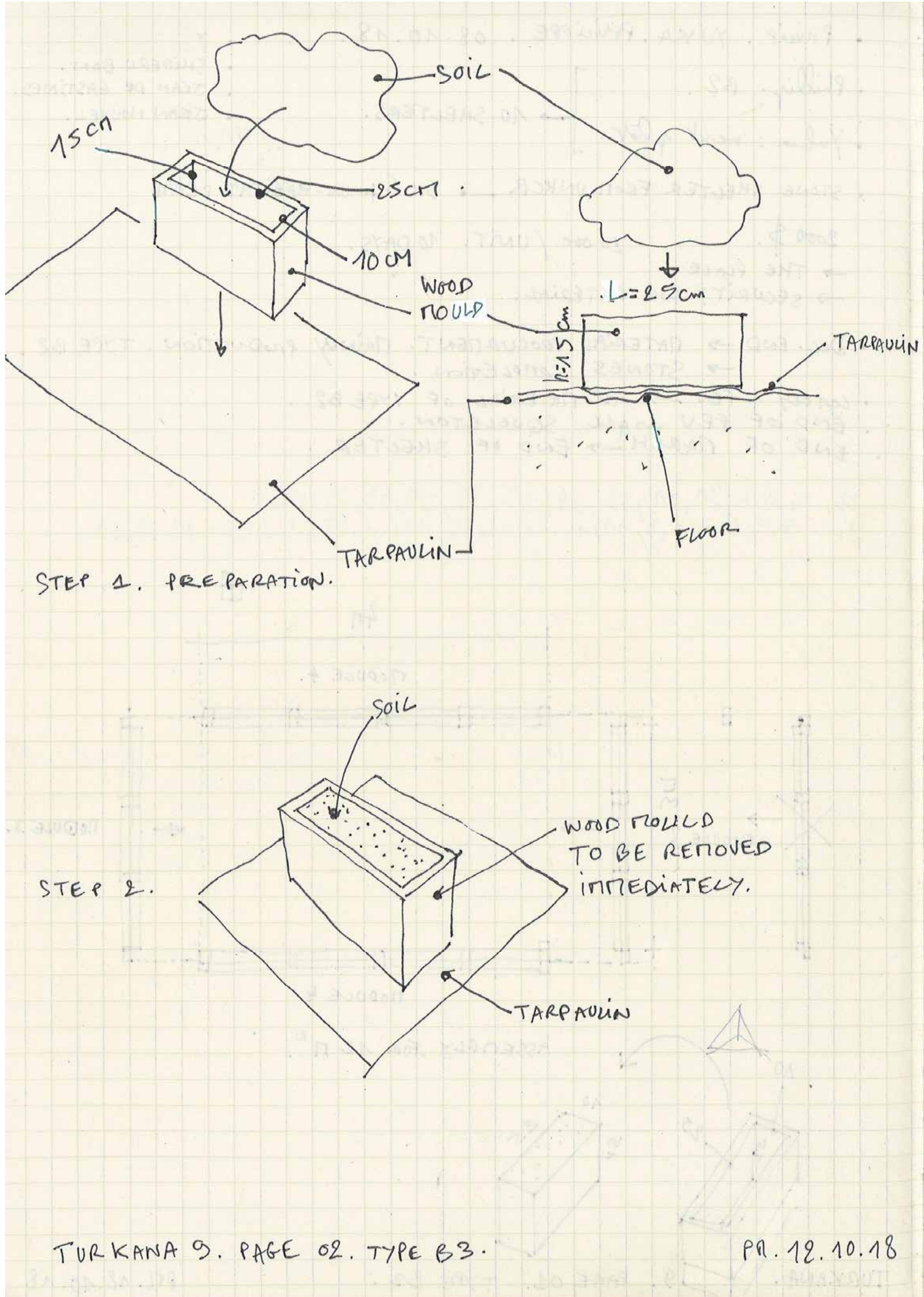

DETAIL 1. PLAN. CORNER.
DETAIL 2. PLAN. 2Π MODULE + 4 Π MODULE.
DETAIL 3. WOOD FRAME.
TURKANA8. PAGE 25. TYPE B2.
PΠ. 20.09.18

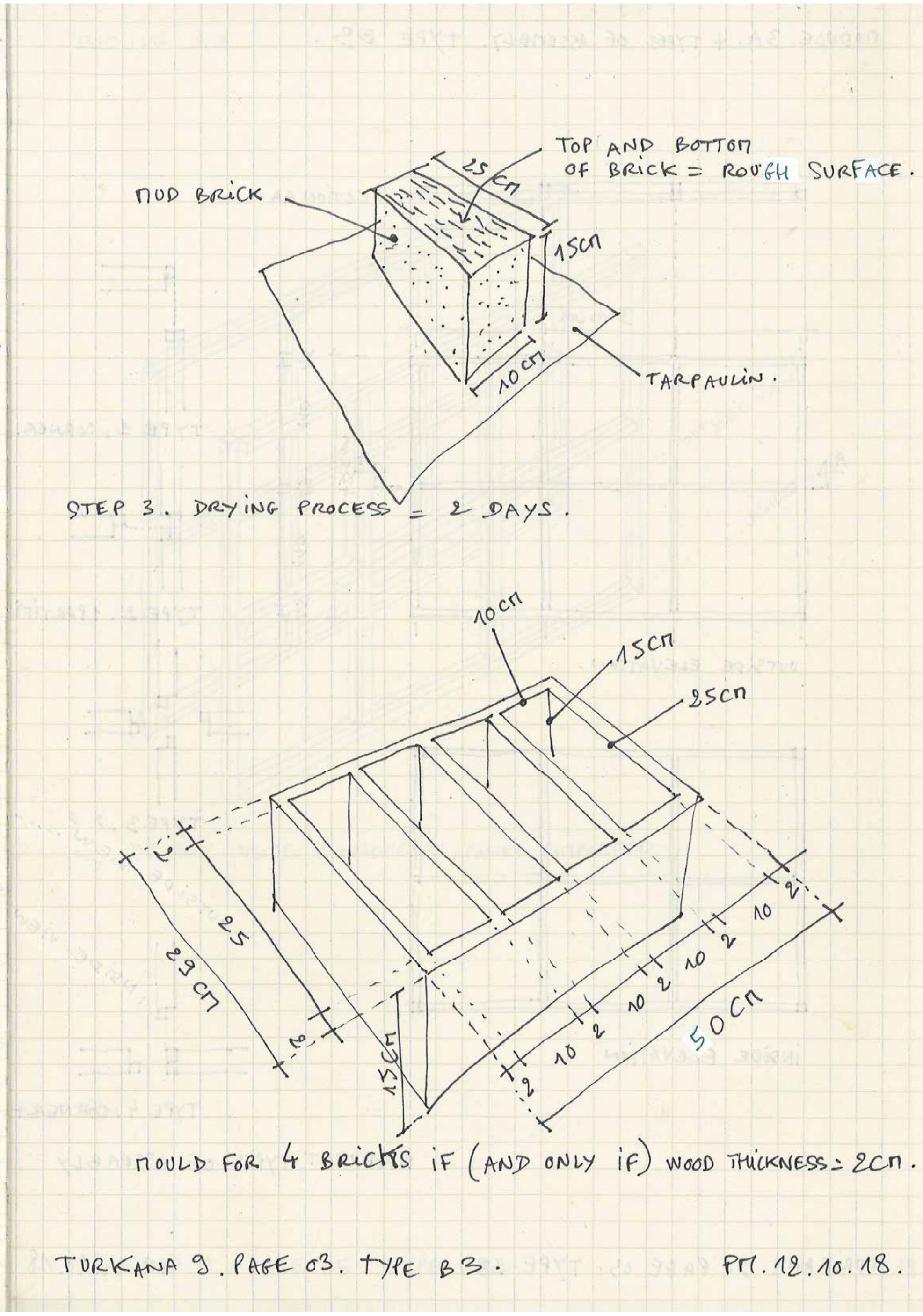

PROPORTIONS.
HOUSE B2 AND PLOT
HOUSE B1 AND PLOT
1. SHOPFRONT.
2. HOUSE (2 ROOMS).
3. OUTSIDE LIVING ROOM.
4. TOILET UNIT.
5. VERANDA.
6. TREE.
TURKANA8. PAGE 28. TYPE B3.
PM. 21.09.18


GARDEN ENTRANCE
TYPOLOGY B1 (TO B3).
STREET ENTRANCE
PLOT + HOUSE. PLAN.
SECTION AA.
SECTION BB
TURKANA 8. PAGE 29. TYPE B3.
PM. 21.09.18.

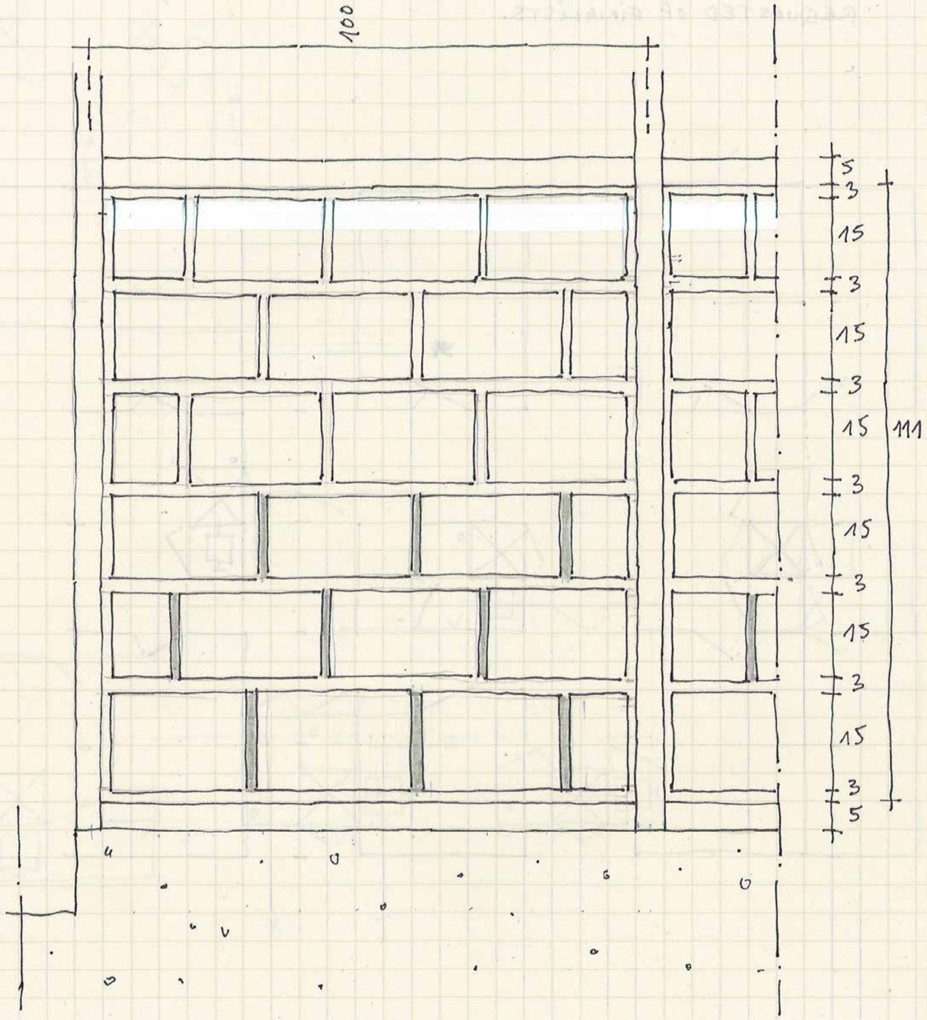

HOUSES WITHIN THE PLOTS. PLANS.
B1
B2
B4
B3
TURKANA 8. PAGE 36. TYPE B3.
PM. 03.10.18.


HOUSES WITHIN THE PLOTS. ELEVATIONS.
B1.
B2.
B4
B3.
TURKANA 8. PAGE 37. TYPE B3
PM. 03.10.18

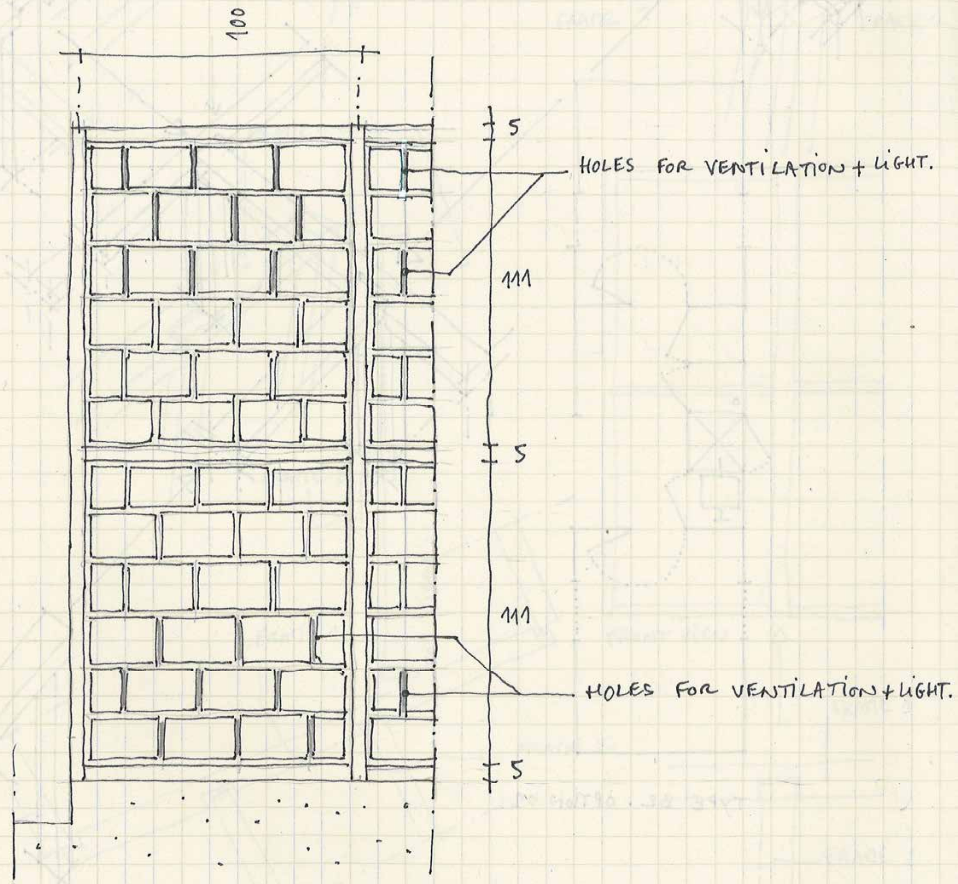

SOIL
15cm
25cm
10 cm
WOOD MOULD
L=25cm
h=15cm
TARPAULIN
FLOOR
TARPAULIN
STEP 1. PREPARATION.
SOIL
WOOD MOULD TO BE REMOVED IMMEDIATELY.
STEP 2.
TARPAULIN
TURKANA 9. PAGE 02. TYPE B3.
PM. 12.10.18


TOP AND BOTTOM OF BRICK = ROUGH SURFACE.
MUD BRICK
25cm
15cm
10cm
TARPAULIN.
STEP 3. DRYING PROCESS = 2 DAYS.
10cm
15cm
25cm
2
25
29cm
2
15cm
2
10
2
10
2
10
2
10
2
50cm
MOULD FOR 4 BRICKS IF (AND ONLY IF) WOOD THICKNESS = 2cm.
TURKANA 9. PAGE 03. TYPE B3.
PM. 12.10.18.

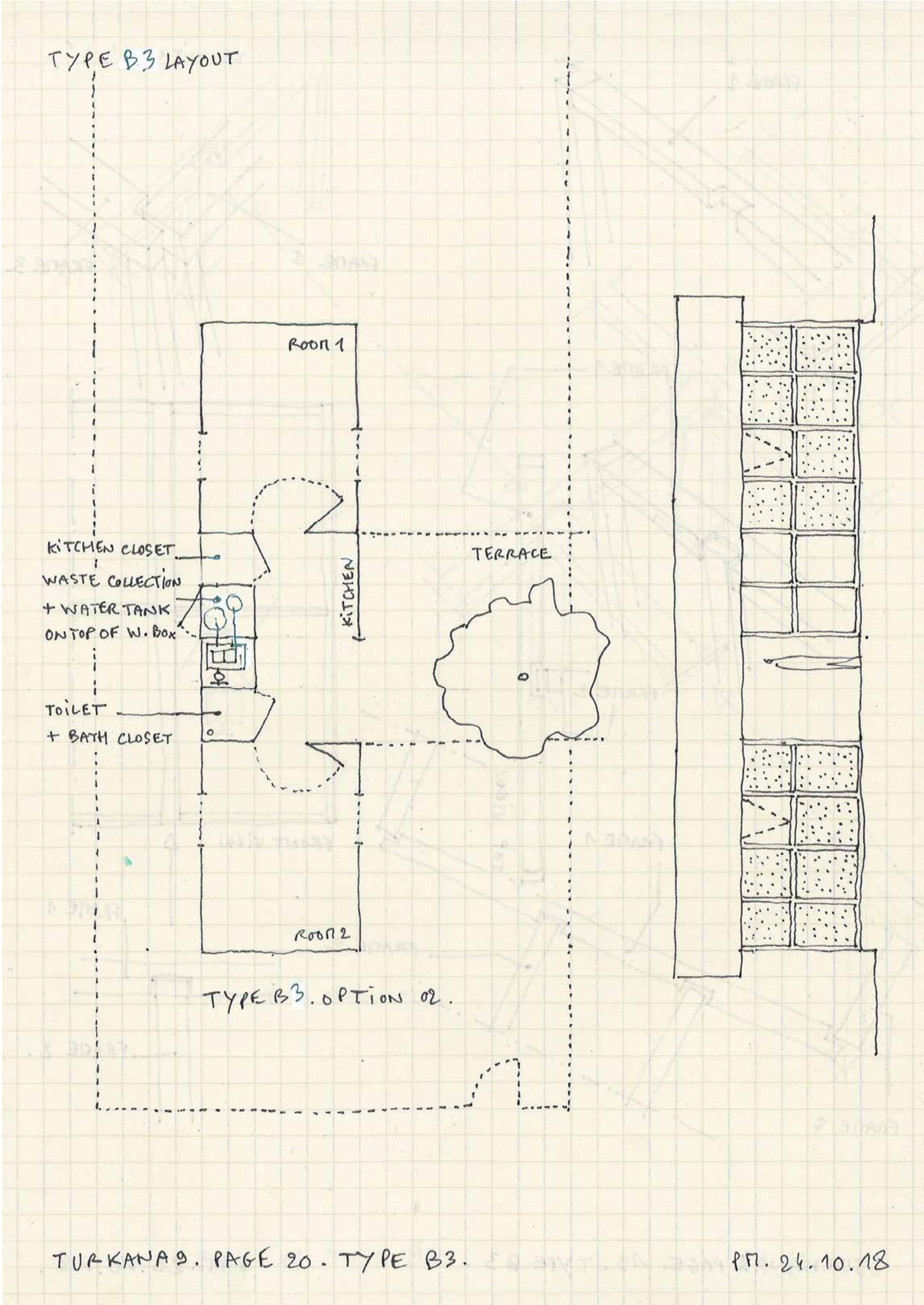
BRICKS LAYOUT. TYPE B3. VENTILATION SYSTEM FOR BATHROOM AND TOILETS.

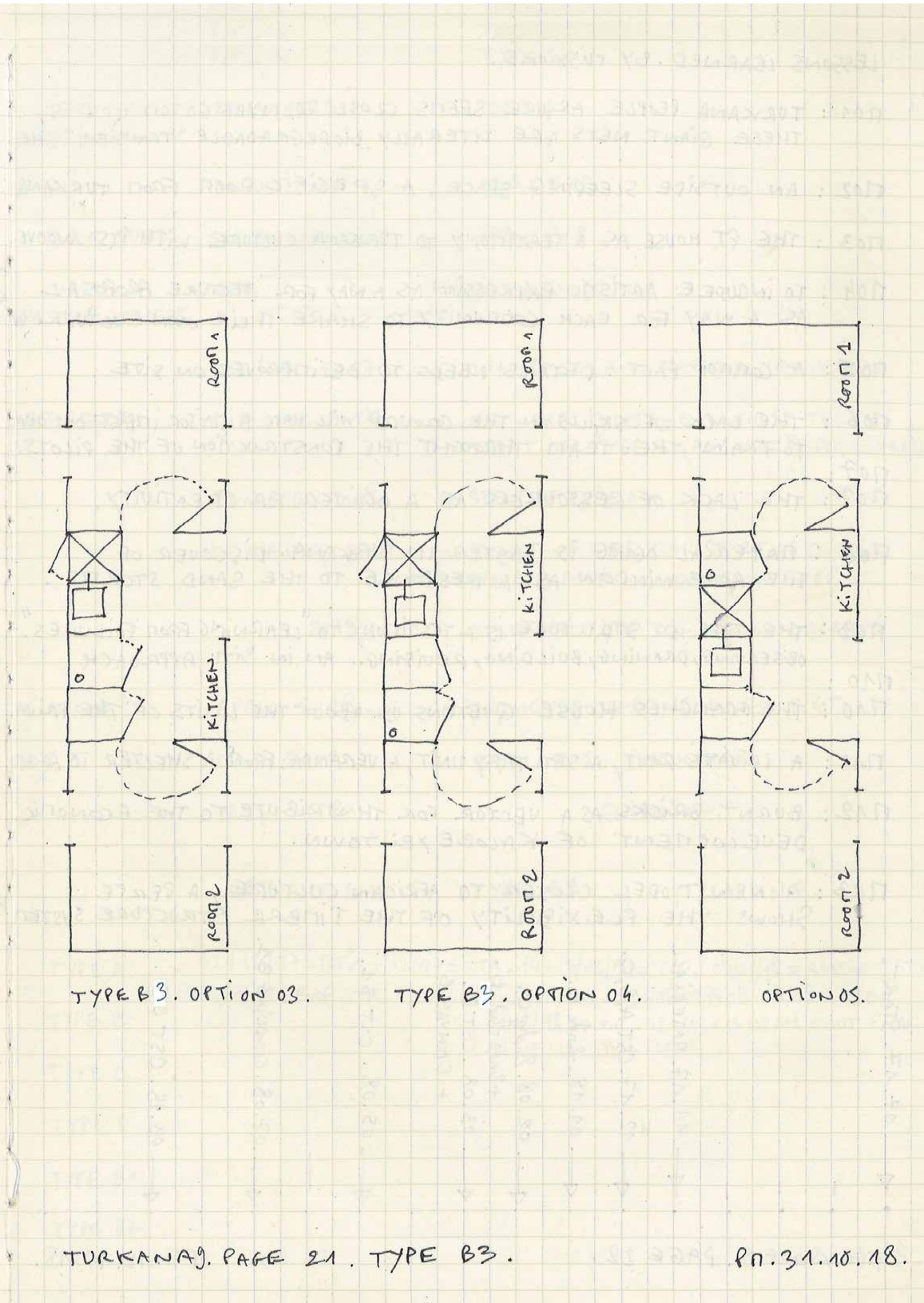


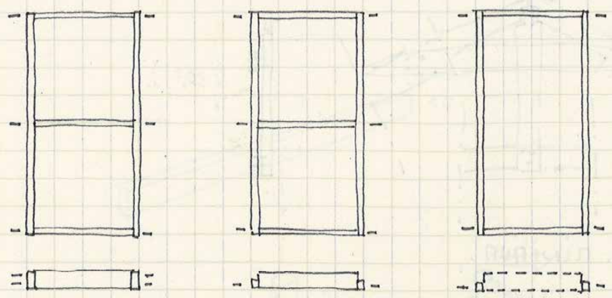
TURKANA9. PAGE 16. TYPE B3. PM. 22.10.18



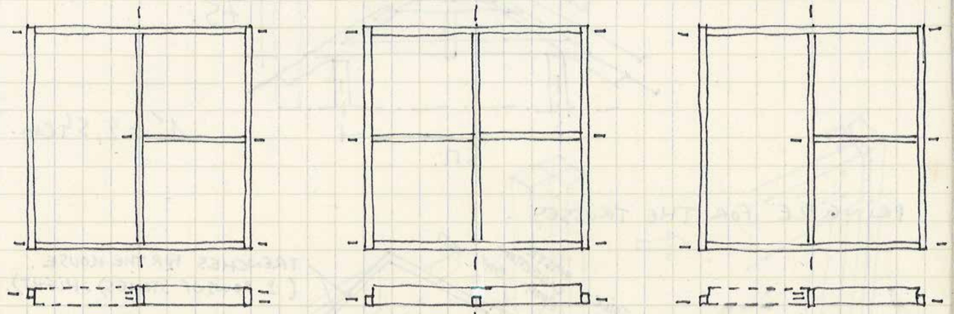
TURKANA9. PAGE 17. TYPE B3. PM. 22.10.18


TYPE B3 LAYOUT
ROOM 1
KITCHEN CLOSET
WASTE COLLECTION
+ WATER TANK
ON TOP OF W. BOX
KITCHEN
TERRACE
TOILET
+ BATH CLOSET
ROOM 2
TYPE B3. OPTION 02.
TURKANA 9. PAGE 20. TYPE B3.
PM. 24.10.18

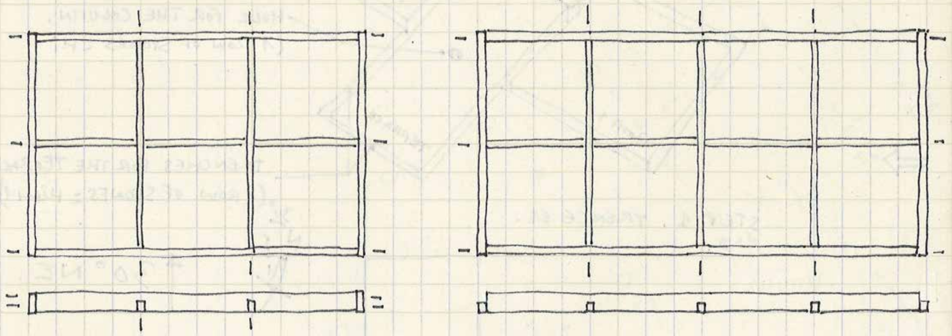

ROOM 1
KITCHEN
ROOM 2
TYPE B3. OPTION 03.
TYPE B3. OPTION 04.
OPTION 05.
TURKANA 9. PAGE 21. TYPE B3.
PM. 31.10.18.



1A (4x). 1B (3x). 1C (1x).

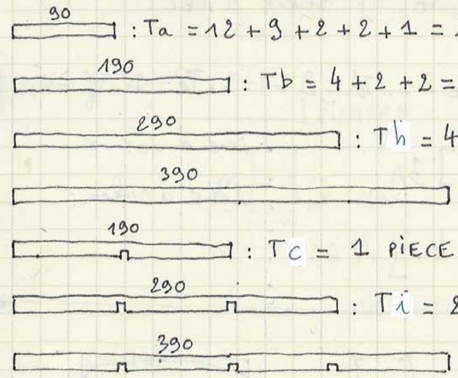


2A (2x). 2B (1x). 2C (1x).



3A (2x). 4A (4x).

TURKANA9. PAGE 32. TYPE B3. PM. 28.11.18.



: Ta = 12 + 9 + 2 + 2 + 1 = 26 PIECES.

: Tb = 4 + 2 + 2 = 8 PIECES.

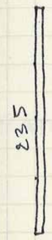
: Th = 4 PIECES.

: Tj = 8 PIECES.

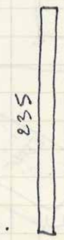
: Tc = 1 PIECE.

: Ti = 2 PIECES.

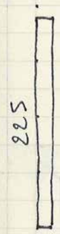
Tk = 4 PIECES.



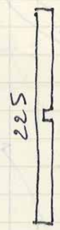
: Tg = 6 + 2 + 2 + 2 + 2 + 8 = 22 PIECES.



: Tf = 8 + 2 + 4 = 14 PIECES.



: Td = 2 + 1 = 3 PIECES.



: Te = 1 + 4 + 12 = 17 PIECES.

TURKANA9. PAGE 33. TYPE B3. PM. 28.11.18.

$84 = (x \times 2) + (3 \times 1). \quad (x \times 2) = 84 - 3 = 81.$

$76{,}5 = (x \times 2) + (3 \times 1). \quad (x \times 2) = 76{,}5 - 3 = 73{,}5.$

$384 = (x \times 10) + (3 \times 9). \quad (x \times 10) = 384 - 27 = 357.$

$1210 = (x \times 32) + (3 \times 31). \quad (x \times 32) = 1210 - 93 = 1117 \rightarrow 34{,}90.$

$1210 = (x \times 31) + (3 \times 30). \quad (x \times 31) = 1210 - 90 = 1120 \rightarrow 36{,}1290$

$420 = (x \times 11) + (3 \times 10). \quad (x \times 11) = 420 - 30 = 390 \rightarrow 35{,}4545455.$

$134{,}25 = (x \times 3) + (3 \times 2). \quad (x \times 3) = 134{,}25 - 6 = 128{,}25 \rightarrow 42{,}75.$

$340{,}5 = (x \times 7) + (3 \times 6). \quad (x \times 7) = 340{,}5 - 18 = 322{,}5 \rightarrow 46{,}0714286$

$340{,}5 = (x \times 8) + (3 \times 7). \quad (x \times 8) = 340{,}5 - 21 = 319{,}5 \rightarrow 39{,}9375$

$134{,}25 = (x \times 3) + (3 \times 2). \quad (x \times 3) = 134{,}25 - 6 = 128{,}25 \rightarrow 42{,}75.$

$174 = (x$

$458{,}4 = (x \times 11) + (3 \times 10). \quad (x \times 11) = 458{,}4 - 30 = 428{,}4 \rightarrow 38{,}9454545$

$420 = (x \times 9) + (3 \times 8). \quad (x \times 9) = 420 - 24 = 396 \rightarrow 44.$

$74 = (x \times 2) + (3 \times 1). \quad (x \times 2) = 74 - 3 = 71 \rightarrow 35{,}5.$

$482 = (x \times 13) + (3 \times 12). \quad (x \times 13) = 482 - 36 = 446 \rightarrow 34{,}3076923$

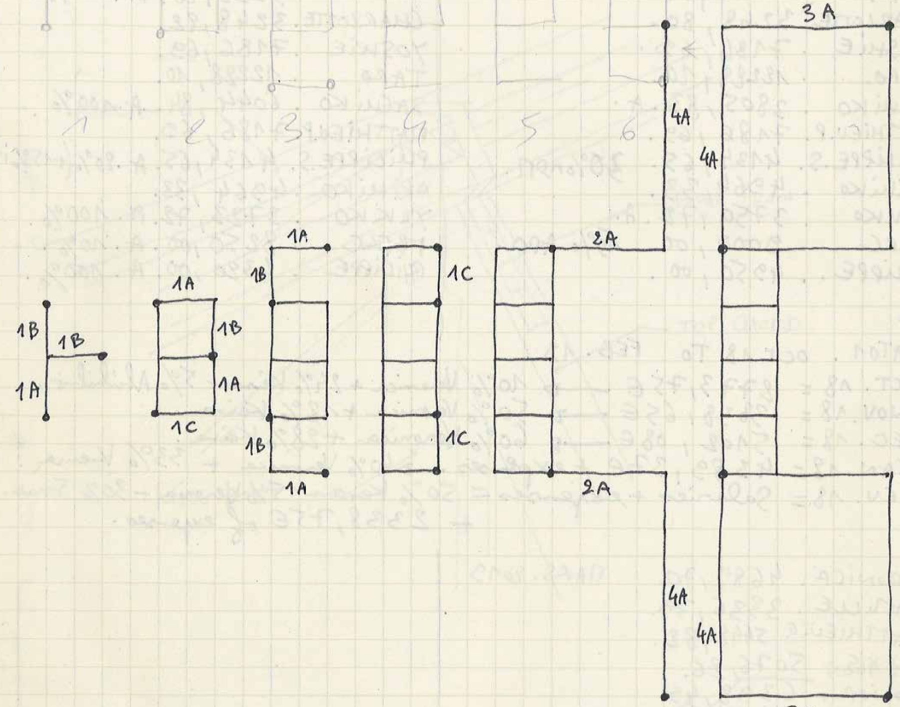
$474 =$

$181{,}5 = (x \times 5) + (3 \times 4). \quad (x \times 5) = 181{,}5 - 12 = 169{,}5 \rightarrow 33{,}9.$

$181{,}5 = (x \times 4) + (3 \times 3). \quad (x \times 4) = 181{,}5 - 9 = 172{,}5 \rightarrow 43{,}125.$

TURKANA 10 . PAGE 14. TYPE B3. PM.09.01.19.

TIMBER FRAME . ASSEMBLY DIAGRAM .



1(1) 2(2) 3(2) 4(1) 5(2) 6(2)

6 PHASES .

10 PAGES .

TURKANA10 . PAGE 15 . TYPE B3 . PM.16.01.19.

Towards Scaled-up Production

Mission M14. Nov. 2018 - Aug. 2019

Customized Bricks

For House B1, I designed the size of the timber frame to match the size of burnt bricks that could be produced in town. However, the bricks were too wide, and we encountered some challenges with the finishes when assembling the frames.
Reflecting on the challenges we faced when building with stone, I started to sketch a mould for the bricks during my previous mission. I was thinking that if we managed to produce bricks that fit perfectly in the wooden frames, mortar application might be easier, and the overall finish would look better. Before leaving last time, I asked Gilbert to fabricate some moulds based on my drawing dimensions. The width of the bricks will be 10cm, matching the width of the timber frames.

October 18th. I land in Kakuma and go directly to Kalobeyei Town to see the moulds. One is complete, and has been carefully constructed with two handles and some metal inside to facilitate the removal of the mud bricks.

A House and Its Tree

October 30th. I meet Shigeru Ban in Paris. He agrees with the idea of two rooms for the next ten houses. However, he wants me to review the plan, and place the main entrance doors in the middle of the short façades to allow for a stronger and more secure structure – something he had already advised earlier. I start to draw the new layout for the ten houses following his recommendation, while keeping in mind the progress of the House B2: more durable foundations, stronger timber structure, and a more localised East African layout. After some days and many tests, a workable plan emerges - a plan with a large outside terrace and a tree in the middle to provide shade.

December 2nd. I send the final layout to the team. It will be the House B3.

New Details for the Site, and Future Details for the Manual

I begin to look for new details beyond the layout. These details will be developed during construction, and will feed into the building manual as improved details.

Foundations

House B1 started with simple poles anchored 50cm in the ground, with mud bricks placed between them. This was easy to set up, but came with a risk of subsidence between the poles. The first solution was to tighten the grid of poles, but this did not stop the degradation of mud bricks after flash floods. We decide to build House B2 on a hybrid foundation system – a mixture of poles and stones. These foundations are stronger but the system is difficult to set-up on the ground. For House B3, I plan to make a simple, stone foundation, and to use hoop irons to attach the boards to the stones.
As we usually do for this type of foundation, I draw a diagram to express the importance of interlocking the stones at the corners. I draw a continuous line between the house and its terrace, to ensure that both will be linked. In the case of flash floods, it will prevent shifting and degradation of the terrace.

Timber Structure

Building House B2 demonstrated that the interlocking system makes the assembly of the frames more efficient and straight, because the profiles are guided by the grooves. This time, we decide to work with 10x5cm profiles instead of 5x5cm nailed together. Our aim is to simplify the fabrication process for the timber frames. In November, I first put the details down on paper and make an inventory of different profiles. After several sketches, I finally complete the work in mid-December.

Fig. 103. Type B3. Moulds (top), raw bricks (middle) and burnt bricks (bottom)

Fig. 104. Type B3. Assembly of the timber frames

In addition to the inventory of profiles for fabrication, I draw a diagram that shows the steps for assembling the timber frames. It is crucial that the builders follow this sequence, and pay attention to the exact measurements specified. These will be clearly shown in the Manual.
Besides researching timber frames, I design some wooden components to cover the exposed corners of the house to prevent water retention. I also describe the principles for pole construction and assembly.

January 15th. I share the Manual with the field team. It includes an explanation of the foundations, the inventory of timber profiles and the timber frame assembly process. This is to ensure that Gilbert and his coworkers can start producing the profiles and setting up the stone foundations. They begin work, with the help of the Manual and informed by their previous experiences building the other pilots.

Construction Without My Supervision

February 15th. I receive the first pictures from the site, which show the foundations of the first house. Unfortunately the house is missing a terrace. Worried, I head to the site on the 25th of February, and realise that the team has built the foundations without terraces. Surprisingly, there are also errors in their alignment. Furthermore, I discover some mistakes in the timber assembly, which are deviations from the Manual (It was either unclear or the team did not use it). I speak to Gilbert, assuming that the team have had difficulty understanding the procedure. I explain a system which might be easier to adopt by drawing a quick sketch on the ground.

February 26th. We go to Natira, the village where the burnt bricks are produced. I am pleasantly surprised to find that production is ongoing and the quality looks good (Fig. 103). However, there is an issue with how the bricks are stored: those placed at the bottom are absorbing moisture from the soil, which compromises their structural integrity. I suggest that two rows of bricks should be placed on the ground, covered with a tarpaulin layer, to provide a dry platform for the bricks that will be used for the houses.

February 27th. I work with the team and on site to produce the timber frames. I realise that they have been fabricating the timber profiles and frames at the same time, instead of first producing all timber profiles as recommended in the Manual. It is necessary to produce all the profiles before assembling the frames. They should be made type by type, to ensure that they are similar and the dimensions are correct. As the team have already produced a large quantity of profiles and frames, I let them continue working in this manner, while checking the dimensions from time to time (Fig. 104).

Fig. 105. Type B3. Foundations of the terrace (front) and burnt bricks ready for use (back)

Further observation reveals that one of the workers is using a hammer made from a piece of wood! This is an unfortunate oversight, as the materials budget would have covered the cost of a proper hammer.
After some time, the team starts on the terrace foundation, with two skilled people building the timber frames. We also receive a delivery of good burnt bricks from Natira (Fig. 105).
Despite some nasty surprises over the last three days, I remain confident that the project will be a success. Back home, I finalise the diagrams and share them with the team immediately, updated accordingly to our agreement on site.

A Team Left to Work on Their Own

In the week after my mission, I receive new photos, and some news - The team has not delivered a shelter with an adequate aesthetic finish. The stones of the terraces have cement on them, there are mistakes in the truss fabrication, and the termite treatment product has been changed without any notice. These mistakes are not structural, but they negatively impact the look of the finished house. This

is the work of a careless team. I see it as a personal failure, and think back to the time when Omari was happy about with our paper tube window constructions for the Type A House; when Sedar was carefully aligning the bricks for Type B; and Gilbert with his beautifully constructed trusses for the branch shelter.
It seems that Gilbert and his co-workers are on their own, with no guidance. I am anxious to go back on site to address the problem.

Revising the Details Once More

While waiting for the next mission, I remember the dangerous winds in Turkana and think about how they might affect the houses. I develop several hoop iron details to find a secure way to attach the roof to the timber structure. Hoop irons are commonly used in addition to nails to reinforce wooden structures in Turkana, because they are cheap and do not require screws. After some sketches, I develop a folded hoop iron detail. I draw two types with a double fold: one to attach the edge purlins to the timber frame, and one to attach the ridge purlins to the kingpost.

March 13th. I am back in Kalobeyei intending to test the hoop iron details. Before starting, I quickly check over the recent progress. There have been some worrying developments. The houses are now aligned on the shorter edges, but not on the longer edges; Four house foundations must be redone for the second time. I advise UN-Habitat to bring back the surveyor to check the plot beacons before restarting the foundation work. There is still cement on the terrace stones, despite my previous instruction to clean it off. The boards that are provided are too thin (some are less than 15mm). I ask that they be replaced with boards of 25mm minimum as specified in the Manual.
The timber work is improving: the team have replaced the termite treatment product and fixed all edges of the trusses.
As I have only a few hours left, Gilbert and I quickly test one of the double folding details for the hoop iron. It appears structurally sound, but the iron's integrity is compromised when the fold is flattened, and it breaks. It was not a good idea after all and I will spend few more days researching and designing alternative hoop iron details.

April 1st. I return to the site to test the new details, but discover further construction errors: twisted timber frames, and roof windows which are not functional. While demonstrating to the team how to shape the edges of the roof window to ensure it can open correctly, I find that the truss dimensions are incorrect - The kingpost is not in the middle, the intermediate chord is not horizontal, and the distance between the top and bottom chord junctions is wrong.

While we fix the truss, I test the two new hoop iron details. They appear to be strong, but I am still not convinced of their structural integrity.
I will later find the solution to the hoop irons by working in 3D. I decide to use 90° folded hoop irons – simple details that can be assembled by unskilled people with little risk (see drawings n°39 and n°40 of the House B3 Manual).

A month later. Due to the rainy season in Turkana, Gilbert and his team request additional time to fix the construction mistakes which I pointed out on my most recent site visit.

Abandoned Houses in the Rain

June 04th. I return to Kalobeyei Settlement to evaluate the progress since my last mission. I see a site that is almost empty. There are only a few unskilled workers around, lacking direction for building.
In the evening, I will find out that Gilbert has been sick since yesterday.
Walking through the site, I discover that the houses filled with bricks are leaning to one side; others standing with only their timber skeletons are also leaning; and the terrace foundations are sinking.

Fig. 106. Type B3. Close-up on Idi's work. Application of the Manual, step 26

A pile of burnt bricks and pieces of wood are left exposed outside the shelters. The bricks on the bottom of the pile are partially decomposed, having absorbed the soil moisture like sponges.
On entering the houses that were filled with bricks, I discover a daub of mortar had been applied to the bricks. The workmanship is poor and the importance explained before of revealing the brickwork and wood is not reflected.
Approaching the timber skeleton structures, I discover as many leaning, twisted profiles, with grooves appearing in areas that did not need them. Some of the frames are too short, while others are too long. I realise that the problem is not the complexity of the structure, but is simply an issue of measurement.
I suspect that Gilbert had increased the size of his team with more unskilled workers, creating imbalance between the total skilled and unskilled people. Perhaps the team felt pressured to complete construction more quickly. At this moment, I find it hard to imagine that these houses will be inhabited one day.

Hope

June 05th. I dig deep and find the resilience to continue. Since we only have a few days and Gilbert is sick, we go on site with Idi[29], another skilled worker, to see what can be fixed. It is impossible to fix all the mistakes in the short term.
Inspecting the timber frames more closely, I realise that there is a building error in the center of every house, due to an error in the fabrication of the panel type 2A. I suggest that we work on improving one house to show the team how to assemble the timber frames properly. We begin by removing all the timber walls, then we fix the level of the foundation boards and work on improving each timber frame. The work consists of straightening some profiles, filling wrong grooves, and replacing some pieces of wood. After this is done, we reassemble the timber frames on the foundations and continue to fix the roof windows (Fig. 106), ending by reattaching the trusses to the structure.

June 07th. We fixed the designated house in two days. The experience gives me hope.

The four houses filled with bricks remind me of old houses approaching the end of their lifespan with little opportunities for revitalization. We may manage to do some minor corrections, but improving issues beyond structural support will be difficult. However, Idi gives me some hope for the four houses next to the church. It was him that I saw in February creating grooves on the timber with his handmade wood hammer! Despite a persistent problem with his leg, it is also him who climbs on the structure and nails it down. I believe that his energy will help Gilbert to recover, and together they will lead a quality team.

Fig. 107. Type B3. Idi and Isaac apply cement finish to the bedroom floors

July 3rd. I return to the site. Idi and Gilbert are working together, one on roofing and the other on the doors and windows. They have fixed all the foundations, except one that still needs to be corrected. They have not yet had time to work on

Fig. 108. Type B3. Ekai applies the ballast flooring to the veranda

Fig. 109. Type B3. A house with an existing tree that suffered from wood harvesting

Fig. 110. Type B3. The outside living space. When I took the photograph, I noticed that the doors at the back were installed on the wrong side. Small details like these need to be corrected on an ongoing basis

the four brick houses, and still need to fix the timber frames. However, I can sense their motivation: the pleasure of doing a good job is back!
As I am here only for a few hours, I test the hoop iron details that I drew for the Manual. They work well. Returning to Nairobi, I feel a sense of relief.

August 19th to 23rd. I am back in Kalobeyei to work on the flooring of the Houses. In the bedrooms, we will apply a simple technique that we already tested in a former shelter: compacted soil covered with ballast, and 3cm of cement on the surface. For the terraces and verandas, I suggest adding a layer of ballast on top of the compacted soil, hoping to avoid a muddy surface during the short but heavy rainy season. While Idi and Isaack are working in the bedrooms (Fig. 107), Ekai is applying the finish to the outside living spaces (Fig. 108). The House B3 construction is now on track, despite a few mistakes here and there (Fig. 109 and 110).
While on site, I look closely at the earlier pilots. Analysing the mud brick skirting in Types A, B and D, I realise that it would make sense to replace the mud bricks with a row of stones, as we did in our last houses. This would reduce the need for constant repairs after the rains. More importantly, I see that the ISSB cladding is in a bad condition due to rain damage. I will need to return soon to solve this issue.

Lessons Learned. The Importance of Team Work

Moving to a larger scale of production has revealed the need for adequate on-site supervision of the construction team, to prevent errors. The last mission in June felt like déjà vu: the same mistakes from previous missions were repeated. As soon as I took a step back and left the team to work independently, I noticed that Gilbert and his team were not nearly as motivated as they were during the construction of our initial experiments - Type A, B, C and D. This is probably due to shifting priorities, and understandably so, as they live within the settlement and must provide for their families' basic needs.
On the other hand, I am confident that the team has enjoyed producing good details, and remembers the pleasure of a job well done. Our team needs someone that will help Gilbert, Idi, Sedar, Isaac, Ekai, and all the others to work for pleasure and not out of pure necessity. A good-quality finish is essential for their dignity.

Following pages: extracts from Sketchbooks n°10. Research for the Manual

. Ta = (12 + 9 + 2) . Tf = 8. Tg = 8.] SERIE 1 ABC.
23

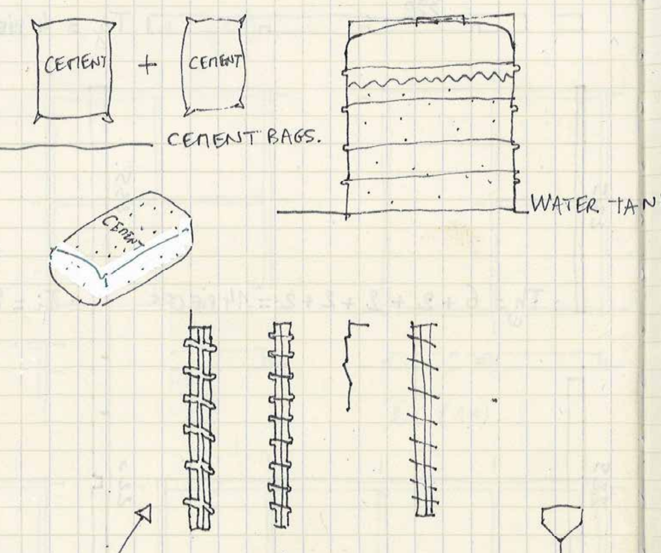
. Ta = 3. Tb = (4 + 2 + 2) = 8. Tc = 1. Td = 2 + 1 = 3. Te = 1. Tf = 2. Tg = 6.] SERIE 2 ABC.

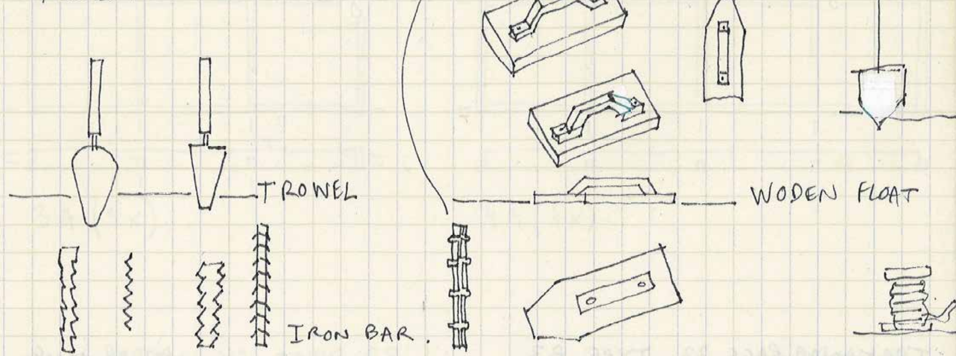
. Te = 4. Tf = 4. Th = 4. Ti = 2.] 3A.

. Te = 12. Tg = 8. Tj = 8. Th = 4.] 4A.

. scie à métaux.
. mèche à ruban.

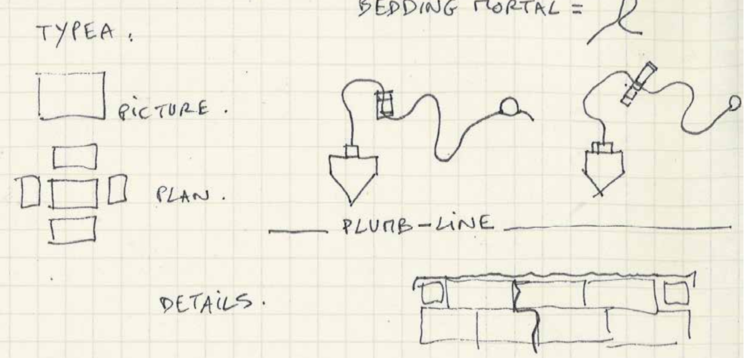
Ta = 23 + 3 = 26.
Tb = 8.
Tc = 1.
Td = 3.
Te = 1 + 4 + 12 = 17.
Tf = 8 + 2 + 4 = 14.
Tg = 8 + 6 + 8 = 22.
Th = 4.
Ti = 2.
Tj = 8.
Th = 4.

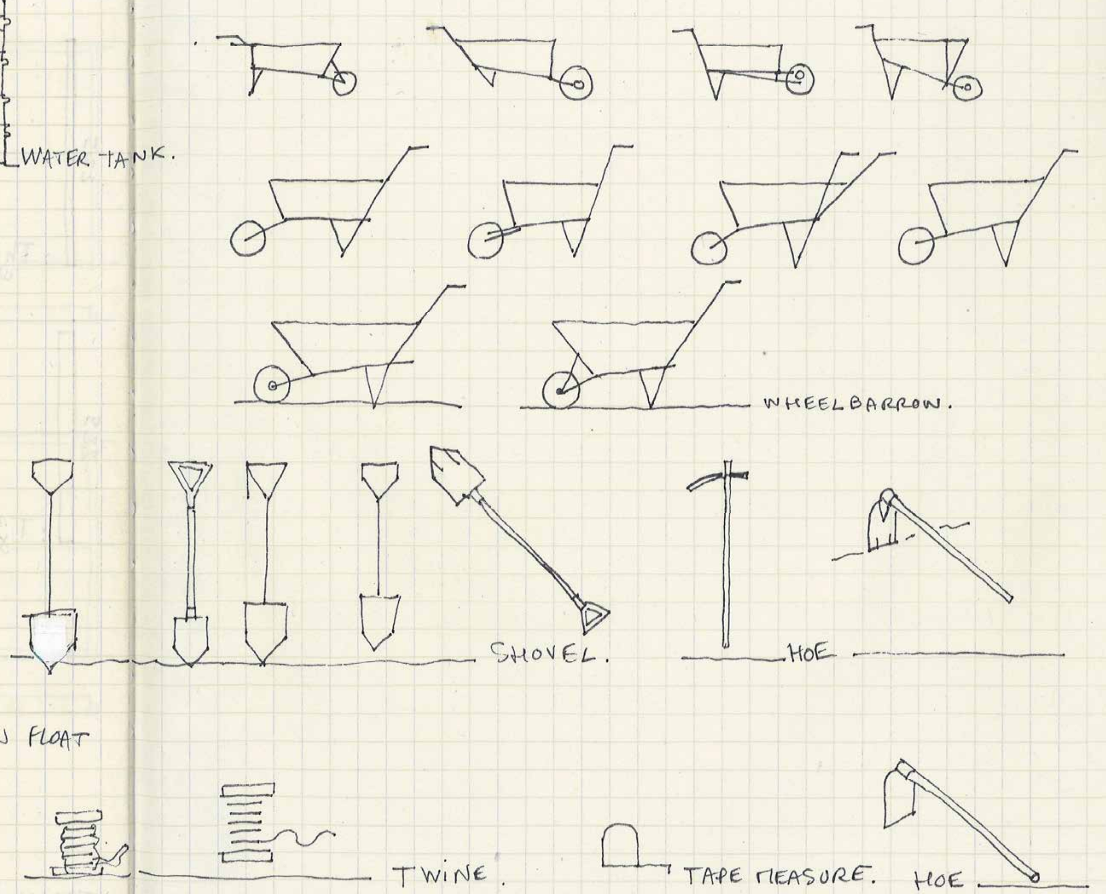




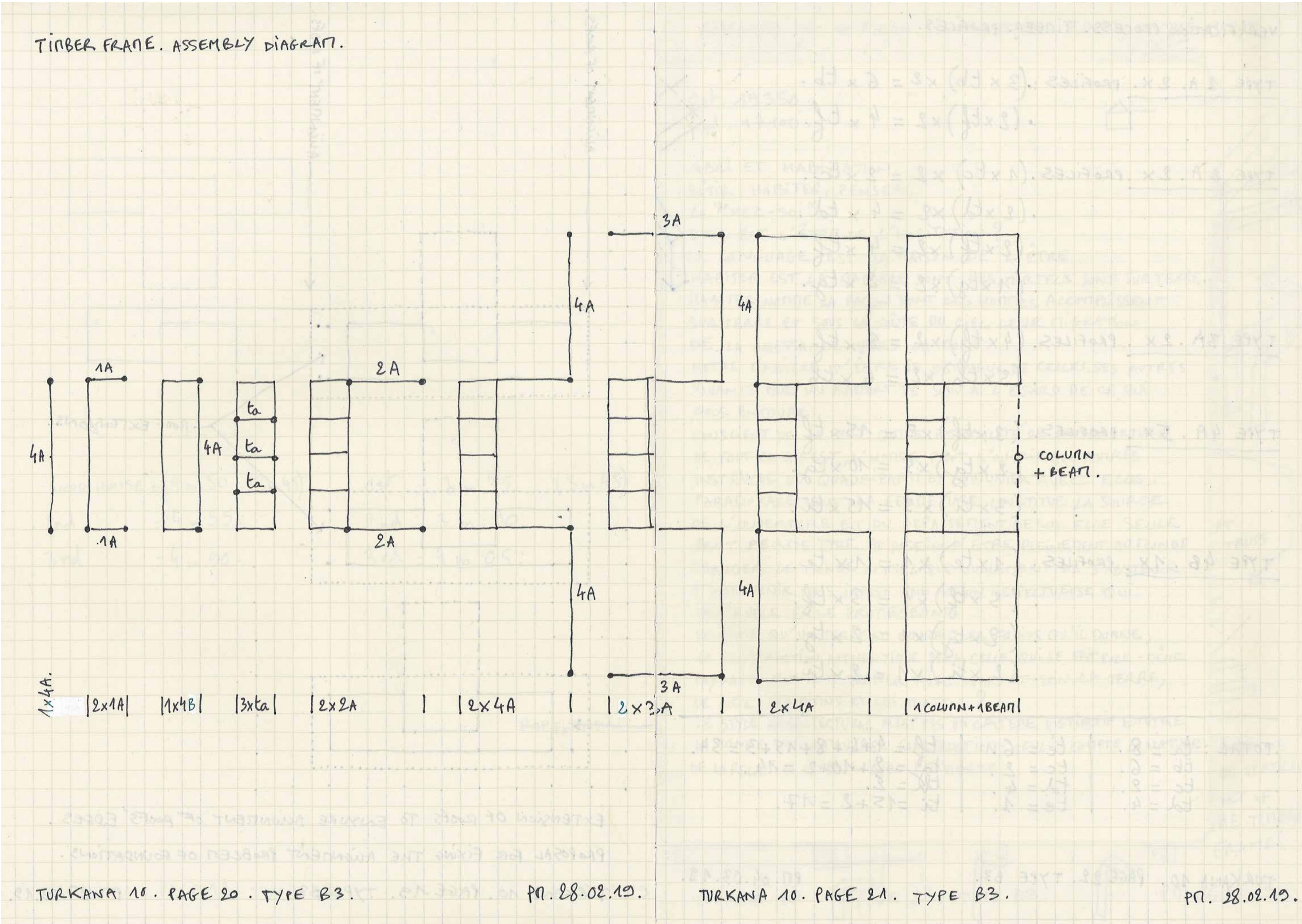
TURKANA9. PAGE 34. TYPE B3. PП. 03.12.18.

BOARDS. LENGHT MAX. = 2,5 cm.





TURKANA9. PAGE 35. TYPE B3. PП. 05.12.18.


TIMBER FRAME. ASSEMBLY DIAGRAM.
4A
1A
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ta
ta
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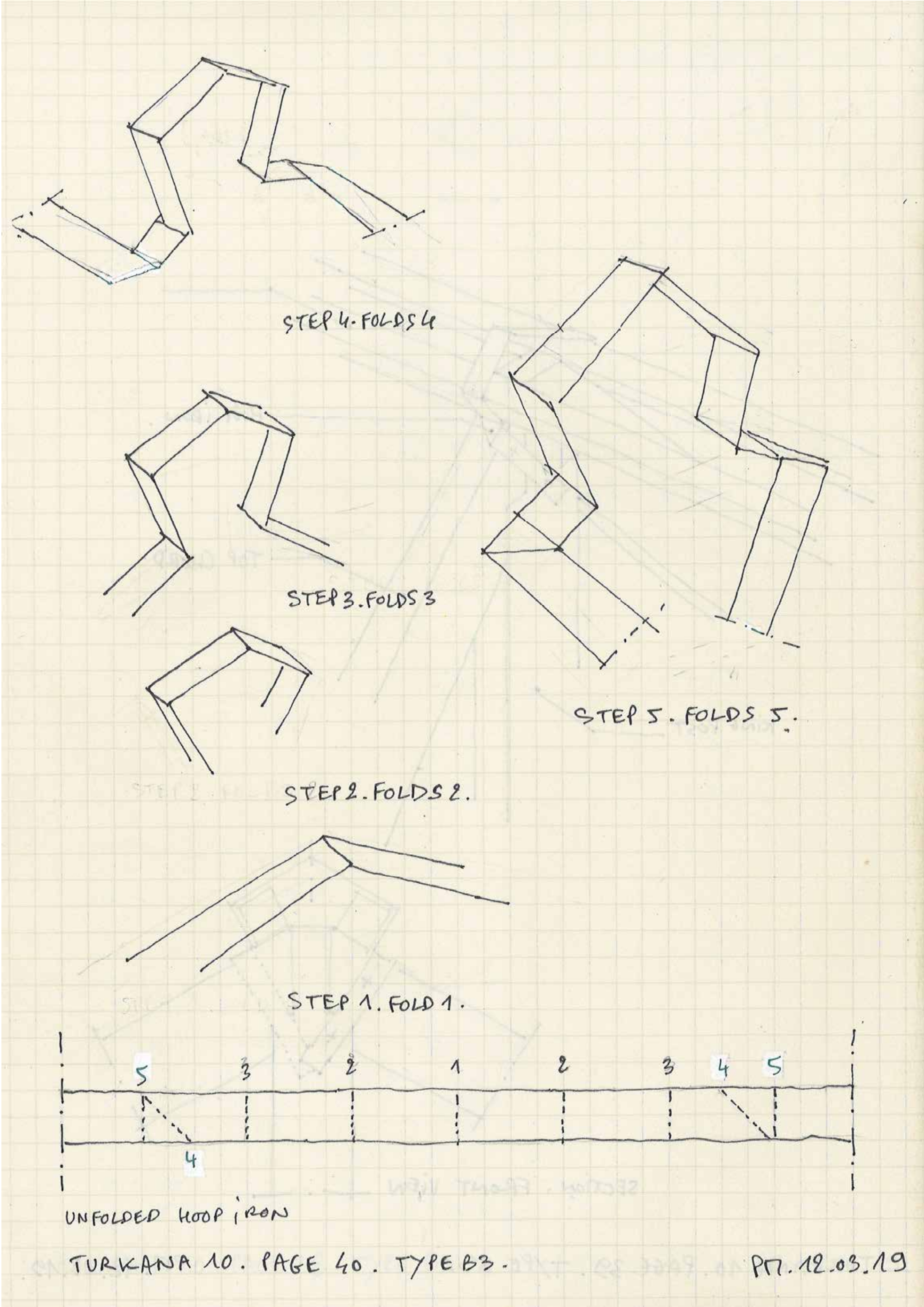
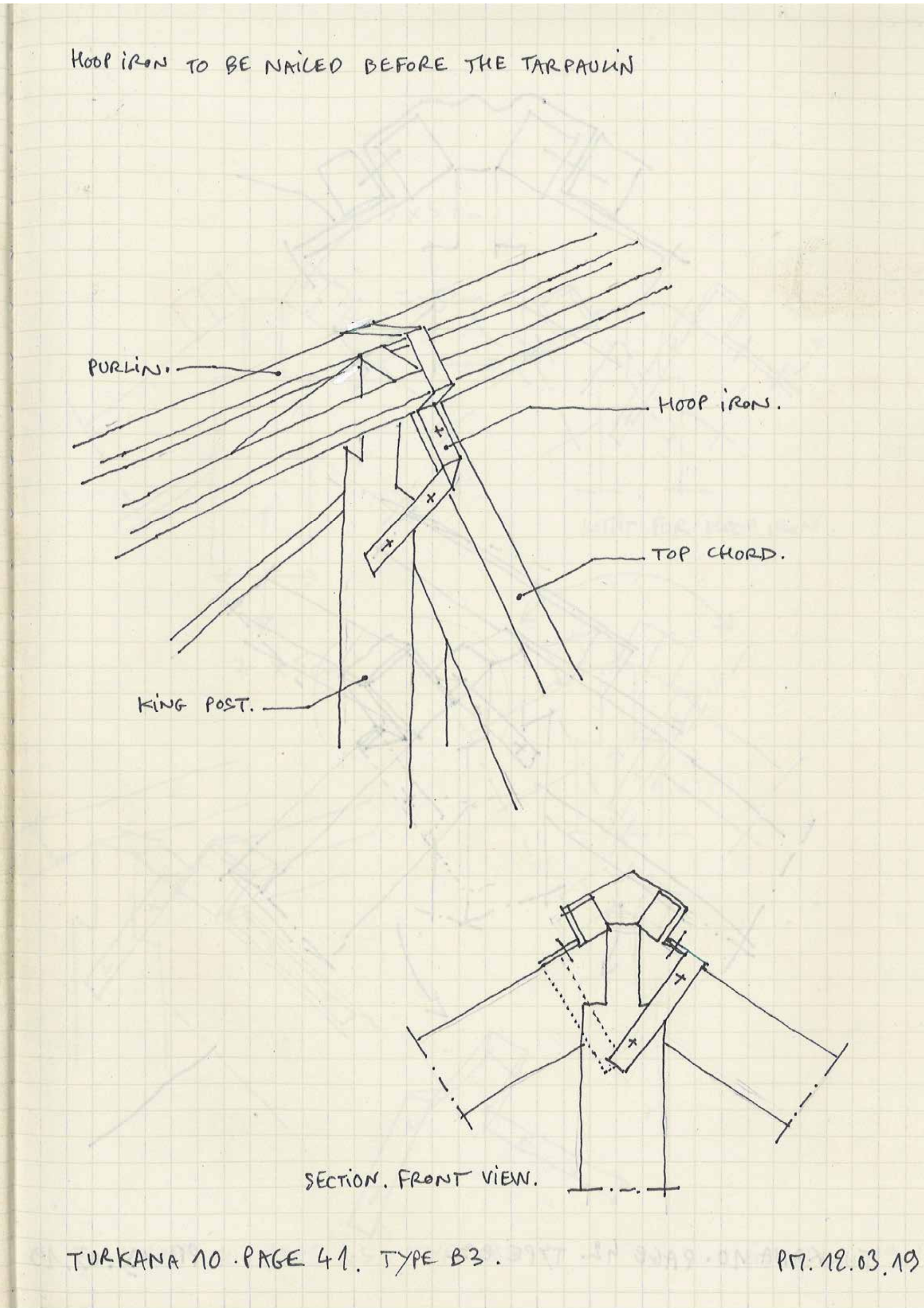
2A
2A
4A
4A
3A
3A
4A
4A
COLUMN + BEAM.
1x4A.
2x1A
1x4B
3xta
2x2A
2x4A
2x3A
2x4A
1 COLUMN + 1 BEAM
TURKANA 10. PAGE 20. TYPE B3.
PM. 28.02.19.
TURKANA 10. PAGE 21. TYPE B3.
PM. 28.02.19.


STEP 4. FOLDS 4
STEP 3. FOLDS 3
STEP 5. FOLDS 5.
STEP 2. FOLDS 2.
STEP 1. FOLD 1.
5 3 2 1 2 3 4 5
4
UNFOLDED HOOP IRON
TURKANA 10. PAGE 40. TYPE B3.
PM. 12.03.19


HOOP IRON TO BE NAILED BEFORE THE TARPAULIN
PURLIN.
HOOP IRON.
TOP CHORD.
KING POST.
SECTION. FRONT VIEW.
TURKANA 10. PAGE 41. TYPE B3.
PM. 12.03.19

A Way Forward

My architectural background is in cultural buildings in Europe. Normally for such buildings, the architect is working with a sizeable budget and an impressive team of experienced clients, surveyors, foundations experts, specialized engineers, highly skilled tradespersons, public institutions, artists, and so on…

When Shigeru Ban and I landed in Turkana for the first time in the summer of 2017, I understood that the architectural proposal would need to be on a different scale, and for a very different part of the world. For Shigeru, the situation was not much of a surprise as he is THE expert on architecture in humanitarian contexts. For me, however, it was a shock.

How would we be able to build with local materials within the parameters of local skills and building techniques? This was my first question.

Working within the Kalobeyei Settlement, we would be faced with the lack of adequately skilled workers, poor-quality materials, a semi-desert climate with unexpected heavy rains, flash floods, sandstorms and an explosive social situation—mixing refugees from different cultures with local Turkana people who are starving. Keeping this in mind, every step of the project became a challenge. With each passing mission, I discovered another way of building in response to the existing conditions. My experience felt anthropological, in the sense that I was learning other ways of living.

The first step was to gain a greater understanding of the local Turkana culture, and that of neighbouring countries such as South Sudan. The second step was to develop contemporary responses based on this research. The final step was to build a team able to construct the pilot houses. In such a process, I felt strongly that I had to fill all the roles—I couldn't rely on specialists, as there were none.

It took us almost a year to build four pilot shelters, experimenting with different building techniques with a constant back and forth exchange between design and construction. The pilots were literally designed on site through construction. The original drawings were mere visions, which were transformed through the construction experience on site.

The pilots were four different interesting techniques and materials, but having only 18m² rooms made it challenging to house entire families.

It was only in May 2018 when we added a terrace and a toilet unit to the design that we could call it a "House". Later, the design expanded to include two separate rooms. At that point, we were no longer providing solutions for transitional or semi-permanent houses, but a permanent, durable house. The final layout is not a design research experiment, but a design response to a specific cultural context.

I remember asking some refugees at the beginning of the exercise: "What would you consider a permanent house?" Most of them answered that it would be built with stones, bricks, or concrete. I took for granted the fact that most of them faced war, fear, horror, and they probably saw their future "in a bunker". They were looking for protection, help, and reassurance of their safety and wellbeing every day. This is probably a post-traumatic reaction; however, I believe that new perspectives can be brought to address this through the medium of architecture.

Over the last two years, we have met with a few refugees who visited our houses, asking us when they can move in. Most of them mentioned the ventilation, the two separate rooms, large windows, and the aesthetics. Once, a refugee passing by the pilot B3 told me: "This house is my former and my future house". At that time, he no longer considered himself a refugee, but simply an inhabitant looking for a home. For him, this was a good house, but that might not be the case for another person.
A South Sudanese refugee may look instead for a house with thick walls, to be protected from bullets. One can imagine that perhaps, in a safer and more stable context, he or she may even adopt the concept of an outside living space.
A Turkana person may look for an outside sleeping space protected by a fence, to feel the cool night breeze and to sleep under the stars. However, in a denser

environment, he or she could then adapt or prefer to sleep inside a room for greater privacy.

There is not one answer. Each context requires a different solution, giving consideration to each culture and the unique opinions of its people. A house is not necessarily four walls and a roof. For instance, the nomadic pastoralists from Turkana County do not see their transient huts as their home. Rather, they see the land as their home. To respond to this need, the following questions must be addressed:
How could the consideration of intangible cultural heritage and the diversity of cultural expressions be incorporated into housing construction?
How could these housing constructions contribute to refugees' sense of self and community identity, and promote greater social cohesion with host communities?
Similarly, how could we build houses that ensure an open dialogue with the people who are living in them, with nature, and with the surrounding environment?

I have been working for two years on the project. Step by step, we came to the design of House B3, a model that is the synthesis of lessons learned from the previous pilot houses. In the second part of the book, I will present the Manual, which explains page by page how to build it.

House B3 is an example of architecture adapted to East African culture. It includes two separate rooms, a large outside living space, a bathroom, and kitchen storage, but it is not a specific answer to the distinct cultural heritage of the Somalis, South-Sudanese, Burundi, Congolese, Turkana people, and others. A way forward would be to develop typologies more reflective of the specific needs and preferences of each community.

House B3 is not a home in itself, but simply a construction that becomes a bridge between people and their environment. It will eventually be enhanced by its future inhabitants and the growth of its natural surroundings. This may help us to progress further in our research.

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3. p.28. The Batujimbar Pavilions were constructed between 1972 and 1975 along the beach of Sanur, a small town on the South-Eastern coast of the island of Bali. Australian painter Donald Friend commissioned his acquaintance Geoffrey Bawa to design a resort of private villas on the beachfront property that housed his existing residence.
"The Sri Lankan Architect Geoffrey Bawa is now regarded as having been one of the most important and influential Asian architects of the 20th century. Bawa came to architecture late, only qualifying at the age of thirty-eight in 1957, but he soon established himself as Sri Lanka's most prolific and inventive architect, establishing a whole canon of prototypes for buildings in a Tropical Asian Context. Although best known for his private houses and hotels, his oeuvre also includes schools and universities, factories and offices, public buildings as well as the new Sri Lankan Parliament". Source: https://geoffreybawa.com/

4. p.39. Tukul definition. Source: https://www.britannica.com/technology/tukul

5. p.42. Facts from UNHCR Sub Office Jamjang. Report on traditional Dinka architecture. 2017 Oct. 19th. Location: Pariang County, Ruweng State, South Sudan. Source of information: Mustafa Kur Lueth Kaman, Field Associate, SO Jamjang, and villagers from Pariang County

6. p.42. Sudd. "One of the largest tropical wetlands in the world, located in South Sudan in the lower reaches of Bahr el Jebel, a section of the White Nile. (...) The wetland serves as a filter that controls water quality and a sponge that stabilizes water flow. It is the major source of water for domestic, livestock, and wildlife use and an important source of fish. The socio-economic and cultural activities of local people are dependent on its annual floods and rains to regenerate floodplain grasses to feed their cattle, as they move from permanent settlements on the highlands to dry-season grazing in the intermediate lands and return to the highlands in May-June when the rainy season starts." Source: https://rsis.ramsar.org/ris/1622

7. p.51. About the Dinka culture. Extract from: *The Dinka of the Sudan*. Deng, Francis Mading. Prospect Heights: Waveland Press, 1972

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http://www.gurtong.net/Peoples/PeoplesProfiles/tabid/71/Default.aspx
https://en.wikipedia.org/wiki/Category:Ethnic_groups_in_South_Sudan

9. p.56. A tarpaulin, or tarp, is a large sheet of strong, flexible, water-resistant or waterproof material, often cloth such as canvas or polyester coated with polyurethane, or made of plastics such as polyethylene. In some places such as Australia, and in military slang, a tarp may be known as a hootch. Tarpaulins often have reinforced grommets at the corners and along the sides to form attachment points for rope, allowing them to be tied down or suspended.Inexpensive modern tarpaulins are made from woven polyethylene; this material is so associated with tarpaulins that it has become colloquially known in some quarters as polytarp. Source: https://en.wikipedia.org/wiki/Tarpaulin

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http://www.shigerubanarchitects.com/works/2005_kirinda-house/index.html

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https://www.nytimes.com/2012/11/15/fashion/15iht-ffabric15.html/

15. p.105. Peace Wind Japan. NGO in charge of the implementation of our pilot houses. About PWJ: https://peace-winds.org/en/

16. **Gilbert Sandja Uledi**. p.123. Refugee from South Kivu, DRC, with a Banyamulenge father and a Babembe mother. 53 years old. Married with five children. Village 2, Kakuma Refugee Camp. Gilbert is a carpenter and a mason, and worked as the site team leader on our project.

17. **Sedar Kibumga Senga**. p.143 Refugee from South Kivu, DRC. Babembe. 43 years old. Married with five children. Village 3, Kakuma Refugee Camp. Sedar is a carpenter and a mason. Gilbert's best friend.

18. p.147. Traditional Arabic houses sometimes have a "Bab irr": a secret door used as an emergency exit built into the walls and hidden with a window sill or a bookcase. The name comes from one of the six gates cut through an ancient wall in Aden (in modern-day Yemen), which was opened only in the event of a state security emergency. In modern-day Spain, the Arab fortress of Benquerencia has a Bab al-Sirr known as the "Door of Treason.". Source and literature:
https://en.wikipedia.org/wiki/Secret_passage
https://www.annefrank.org/en/anne-frank/go-in-depth/history-secret-annex/

19. **Bruno Nabyo Amani**. p.151. Refugee from South-Kivu, DRC. Babembe. Village 2, Kalobeyei Settlement. Bruno is originally an electrician but he will learn carpentry and masonry with Sedar.

20. **Omari Ndikumana**. p.153. Refugee from Burundi. Single. Village 2, Kalobeyei Settlement. Omari worked on all pilots , except B3. Since he left for Nairobi, we have not heard any news from him.

21. **Nyaluak Choul**. p.153. Refugee from Guroro, South Sudan. Nuer. 28 years old. Married with four children. Village 4, Kakuma Refugee Camp. Later, Nyaluak will do all floor finishes for types A, B, C, and D. After each rainy season, she paints her house with designs inspired by flowers. She has a book about flowers.

22. p. 161. Definition of dust devils from The American Meteorological Society. Sources:
https://en.wikipedia.org/wiki/Dust_devil
https://glossary.ametsoc.org/wiki/Dust_devil

23. **Nyaoum Patote**. p.161. Refugee from Guroro, South Sudan. Nuer. 30 years old. Village 4, Kakuma Refugee Camp. She is Nyaluak's friend and they will do the floor finishes for types A to D together.

24. p. 193. Gilbert is carrying one of his famous handmade ladders. It will be necessary to use a small ladder like that in each house for roof windows operation. See page 423

25. p.198. A nod to "The Oak and the Reed", last fable in Book I of *La Fontaine's Fables*. Jean de la Fontaine. 1668

26. **Isaac Nimbona**. p.223. Refugee from Burundi. 27 years old. Single. Village 2, Kalobeyei Settlement. Isaac was living near by the site. He helped us through all processes of construction, and he is now the guard of our pilot houses. Furthermore, he is looking after the conditions of our pilots.

27. **Ekai Nangolol**. p.223. Kalobeyei Town, Turkana. He approched us for work, and he never left the team. He is our 'Turkana Boy', always keen to learn, and doesn't care about where you are from. He is a living exemple of tolerence. His nickname is in reference to "Nariokotome Boy, the name given to fossil KNM-WT 15000, a nearly complete skeleton of a Homo erectus (Homo ergaster) youth who lived at c. 1.5 to 1.6 million years ago. This specimen is the most complete early human skeleton ever found. It was discovered in 1984 by Kamoya Kimeu on the bank of the Nariokotome River near Lake Turkana in Kenya" Reference book: "The origin of humankind". Richard E. Leakey. BasicBooks. 1994.

28. **Moses Uwizeyimana**. p.227. (Punda). Refugee from Burundi. Single. Village 2, Kalobeyei Settlement. When we met him, he was a cook, then part of our team, and now he is a 'boda boda' driver (motorbike taxi). He is a good example of resourcefulness when you live as a refugee.

29. **Idi Mahmoud**. p. 285. Refugee from DRC. 38 years old, single. Village 1, Kakuma Refugee Camp. Idi is an excellent carpenter. He took part in the construction of the last four B3 Houses..

A Few People from the Site

Nyaluak Choul (front) and Nyaoum Patote (back)
Nuer. South-Sudan. Floor finishing

Sedar (front) and Bruno (back)
Window installation - Type C

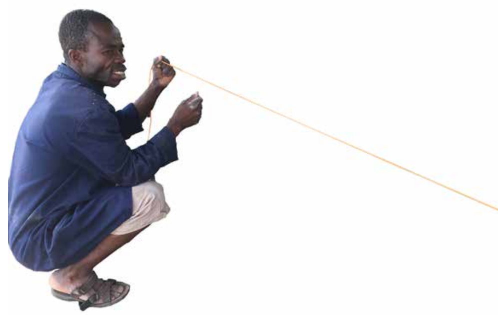
Ekai Nangolol
Turkana, Kenya. Foundations

Moses Uwizeyimana
Burundi. Masonry

Catherine Arot
Turkana, Kenya. Cladding

'Professeur' Gibert Sandja
South-Kivu. DRC. Team leader

Bruno Nabyo Amani
South-Kivu. DRC. Masonry



Sedar Kibumga
South-Kivu. DRC. Masonry, carpentry

Idi Mahmoud
South-Kivu. DRC. Carpentry

Isaac Nimbona
Burundi. Masonry, carpentry

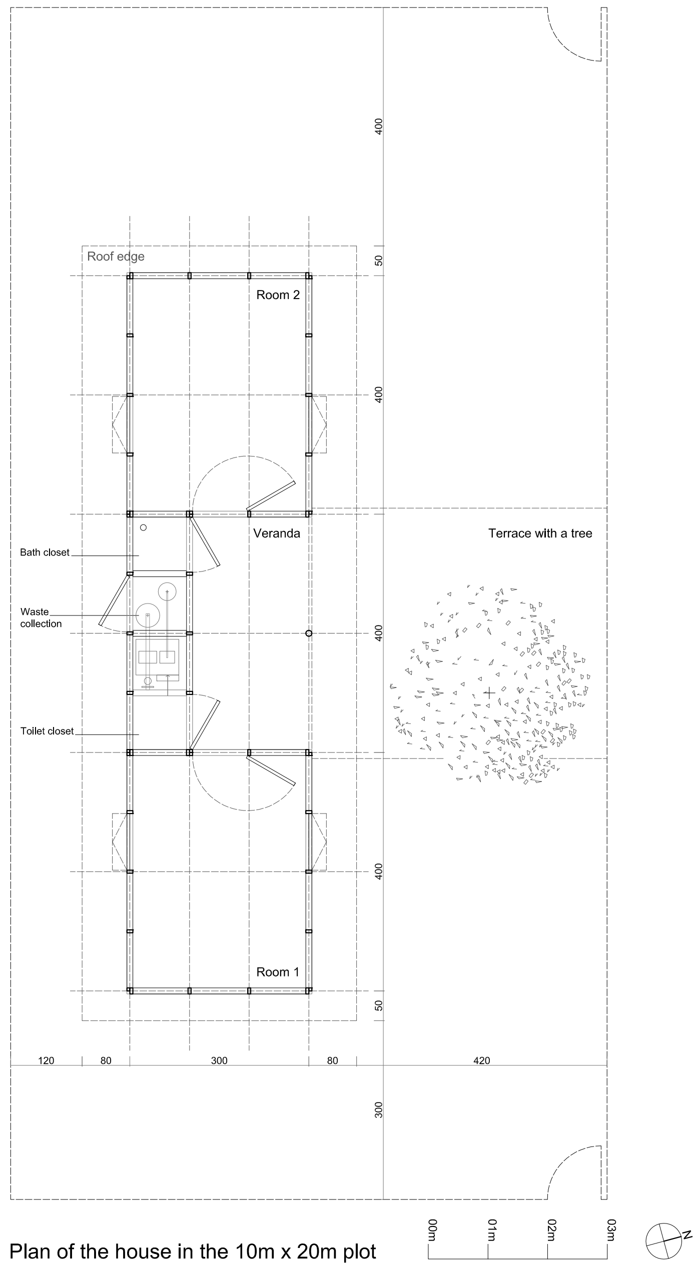
House B3 Manual

Part 2. From An 'in-situ' Approach to a Manual

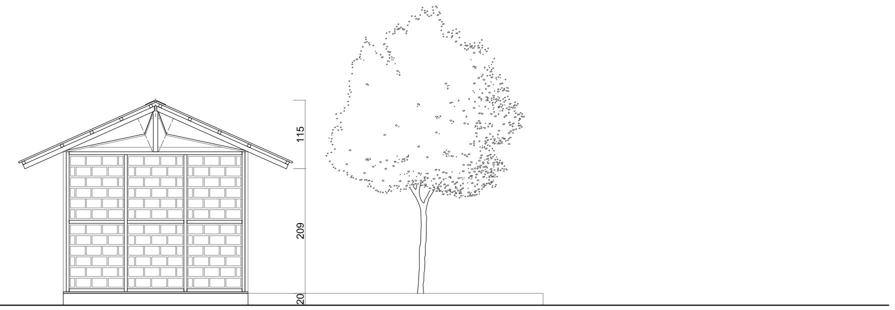
In Part 1, 'Turkana Journal', I have recorded my experiences of working in Kalobeyei Settlement, Turkana County, Kenya, over the last two years. I tried to describe our successes and failures while building the 14 houses, including seven different housing pilots. As I describe in the Journal, the building process was heavily influenced by the local context.
The following pages are a visual interpretation of that process presented as a manual, which explains step-by-step how to build the final pilot, House B3.
As explained in the journal, the design of House B3 is not a perfect solution for all communities, but I hope it reflects what I learned from the site, from Shigeru Ban's expertise, and from all of the people that I met.

Philippe Monteil. Feb. 2020

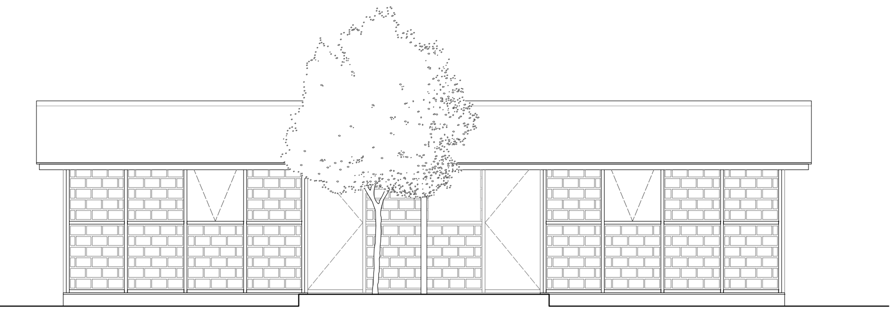
Manual Content



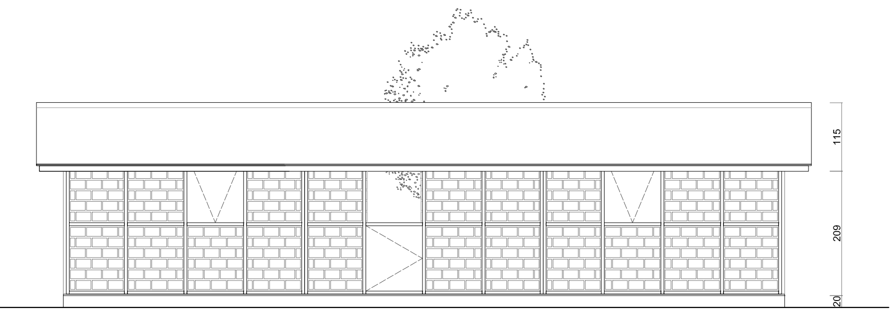
Plan of the house in the 10m x 20m plot



Elevation 120°SE



Elevation 30°NE



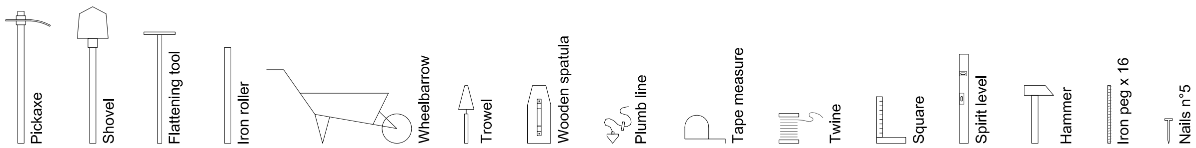
Elevation 210°SO

Elevations of the house

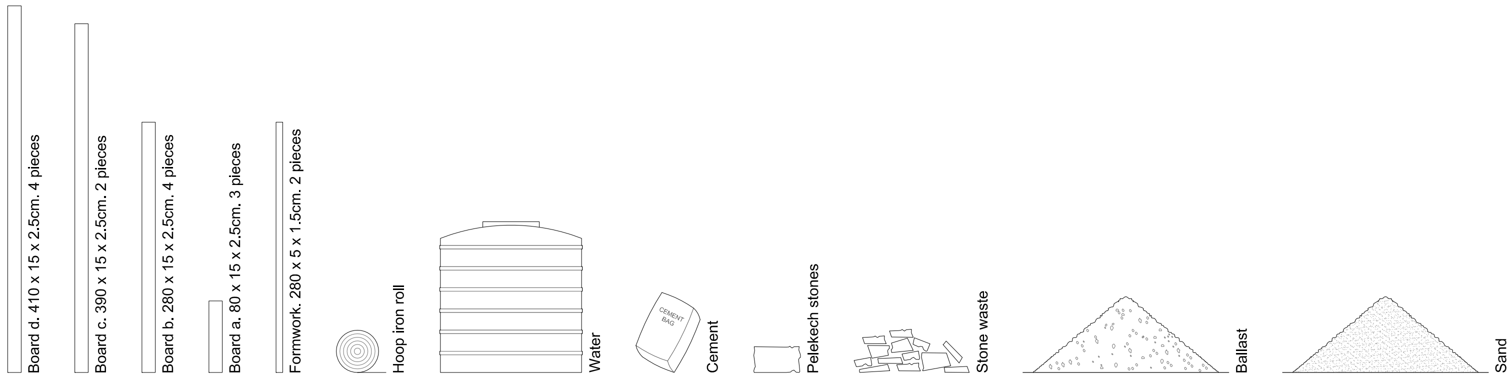
House B3 Manual

Layout of the House. 01

Foundations

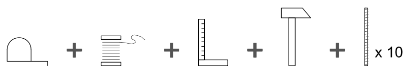


Tool inventory

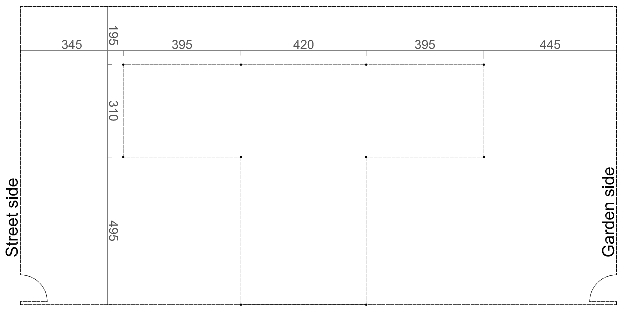


Material inventory

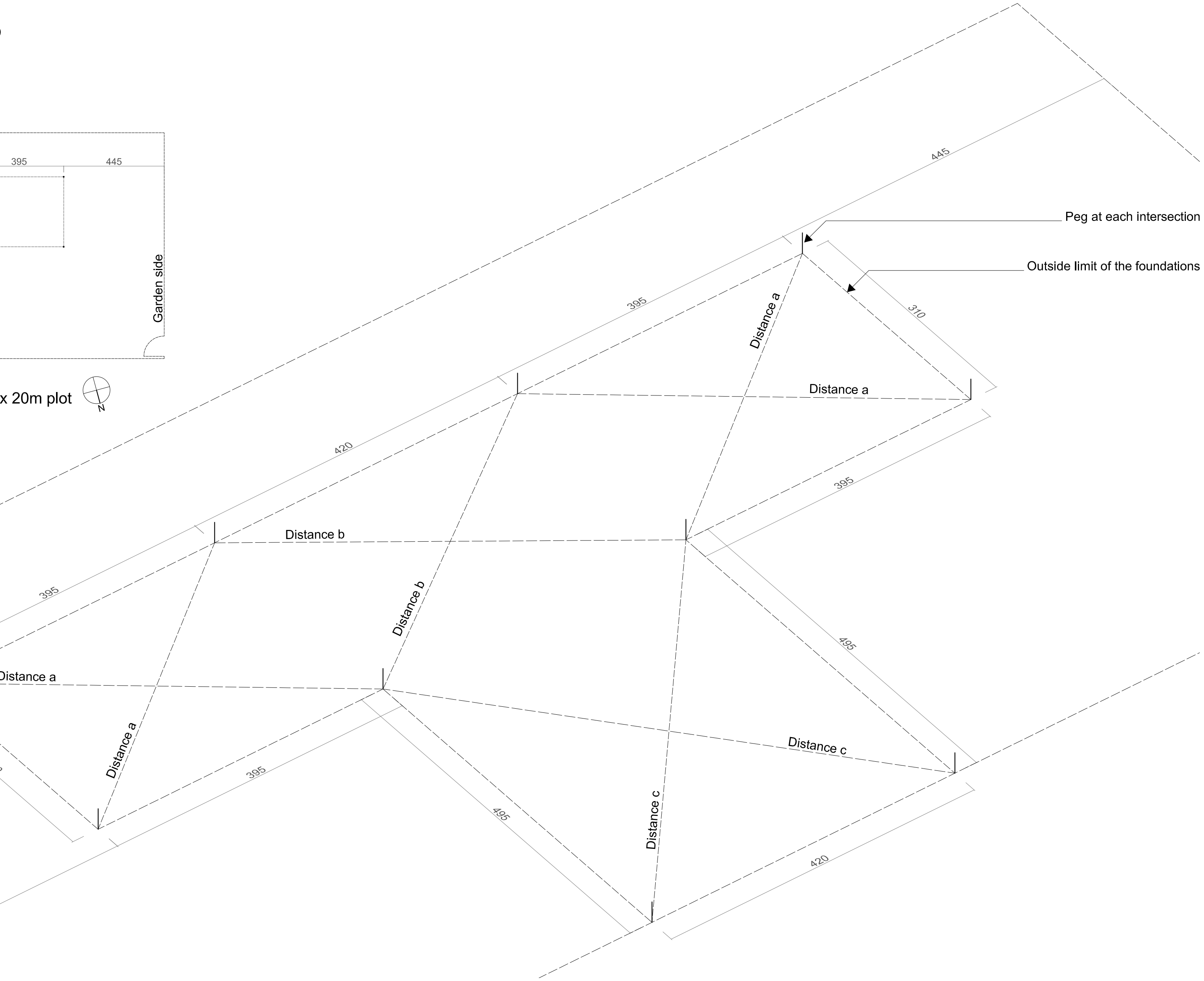
Inventory



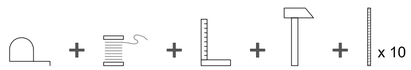
Required tools



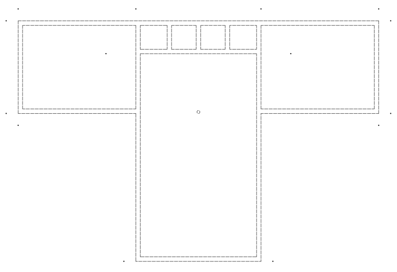
Outside limit of the foundations in the 10m x 20m plot



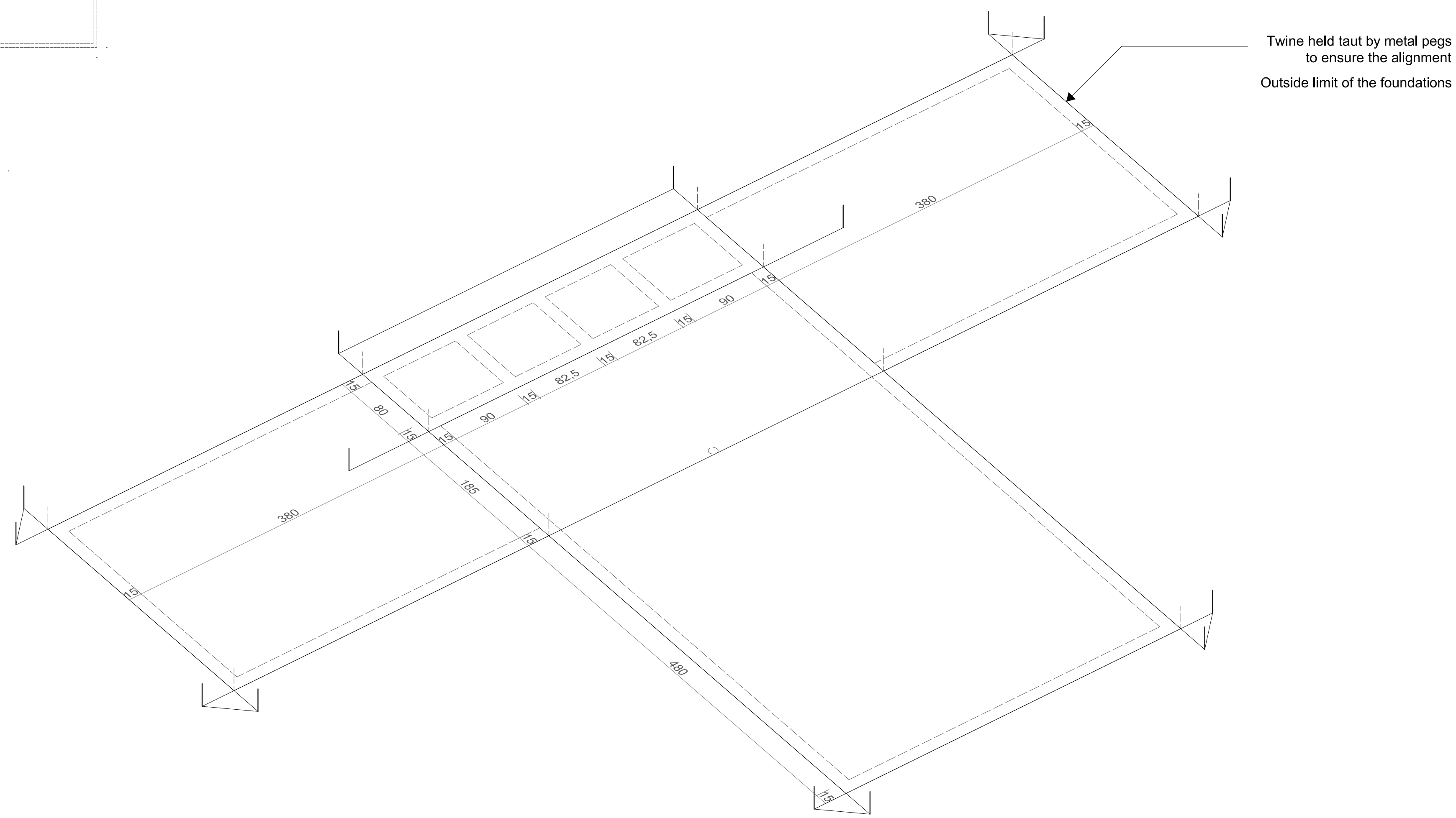
Marking the outlines of the foundations



Required tools



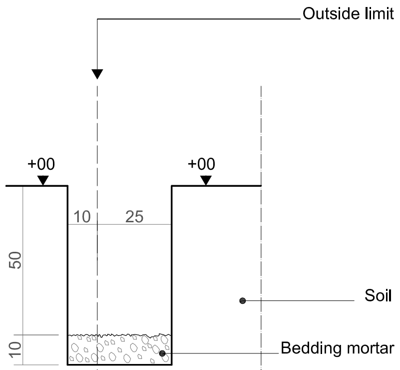
Foundations diagram



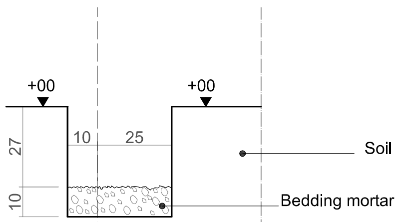
Tracing the foundations before digging

House B3 Manual

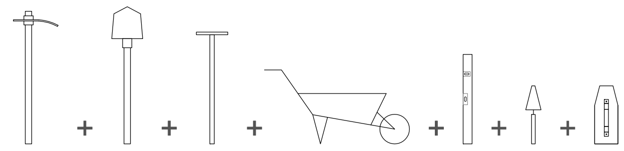
Foundations. 04



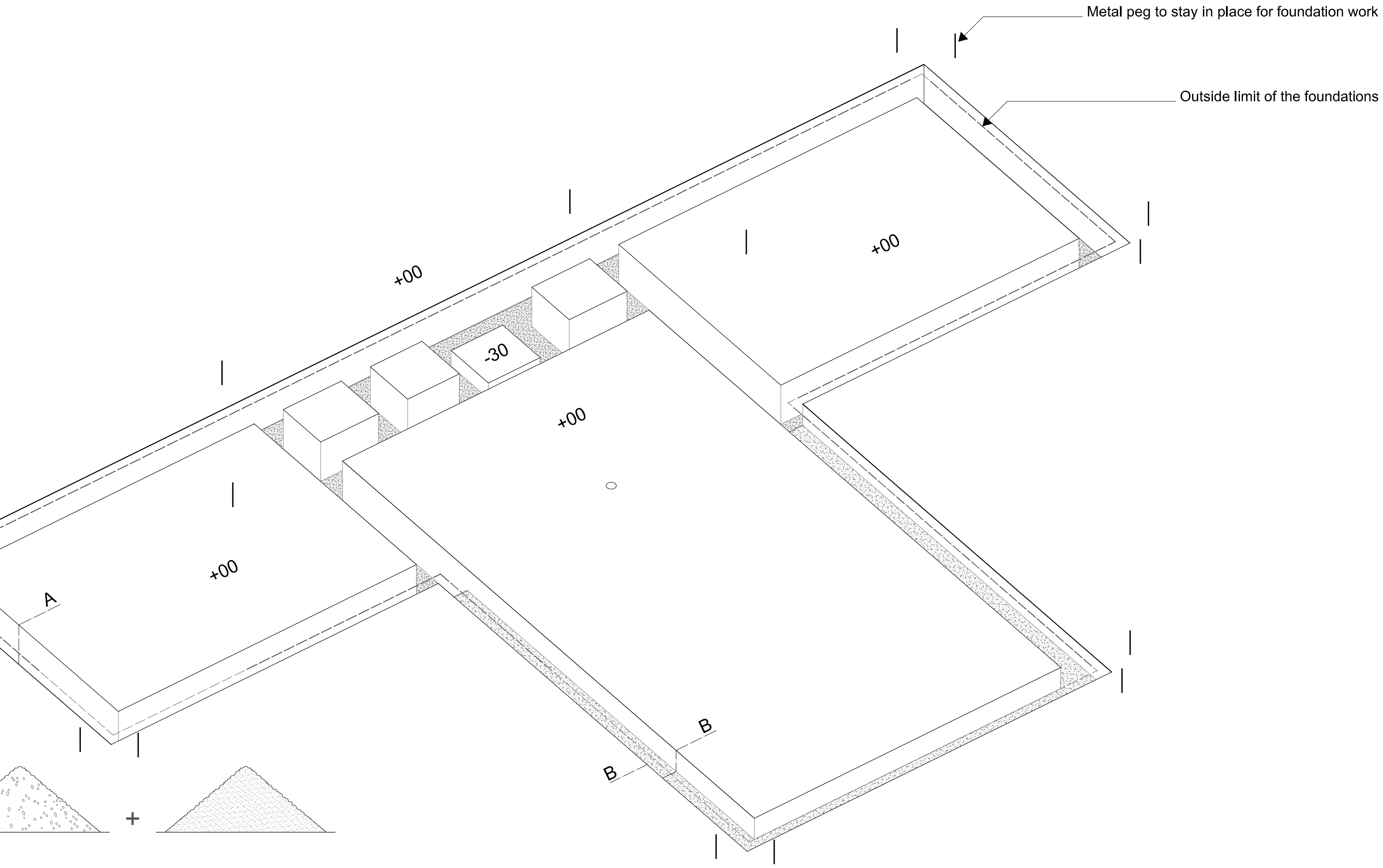
Section AA. Rooms. Trench 60cm deep

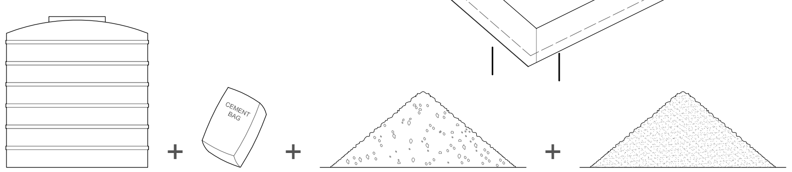


Section BB. Terrace. Trench 37cm deep



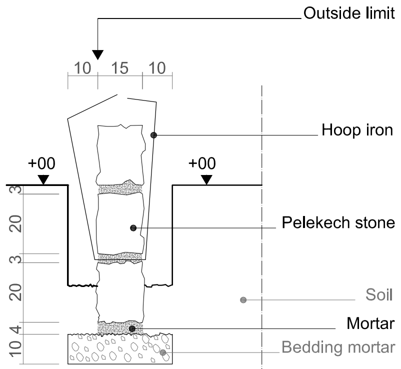
Required tools



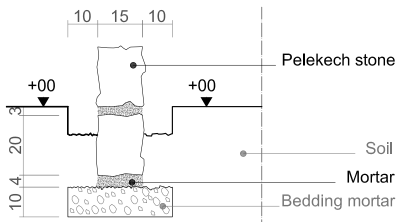


Required material for the bedding mortar

Digging the trenches + bedding mortar application

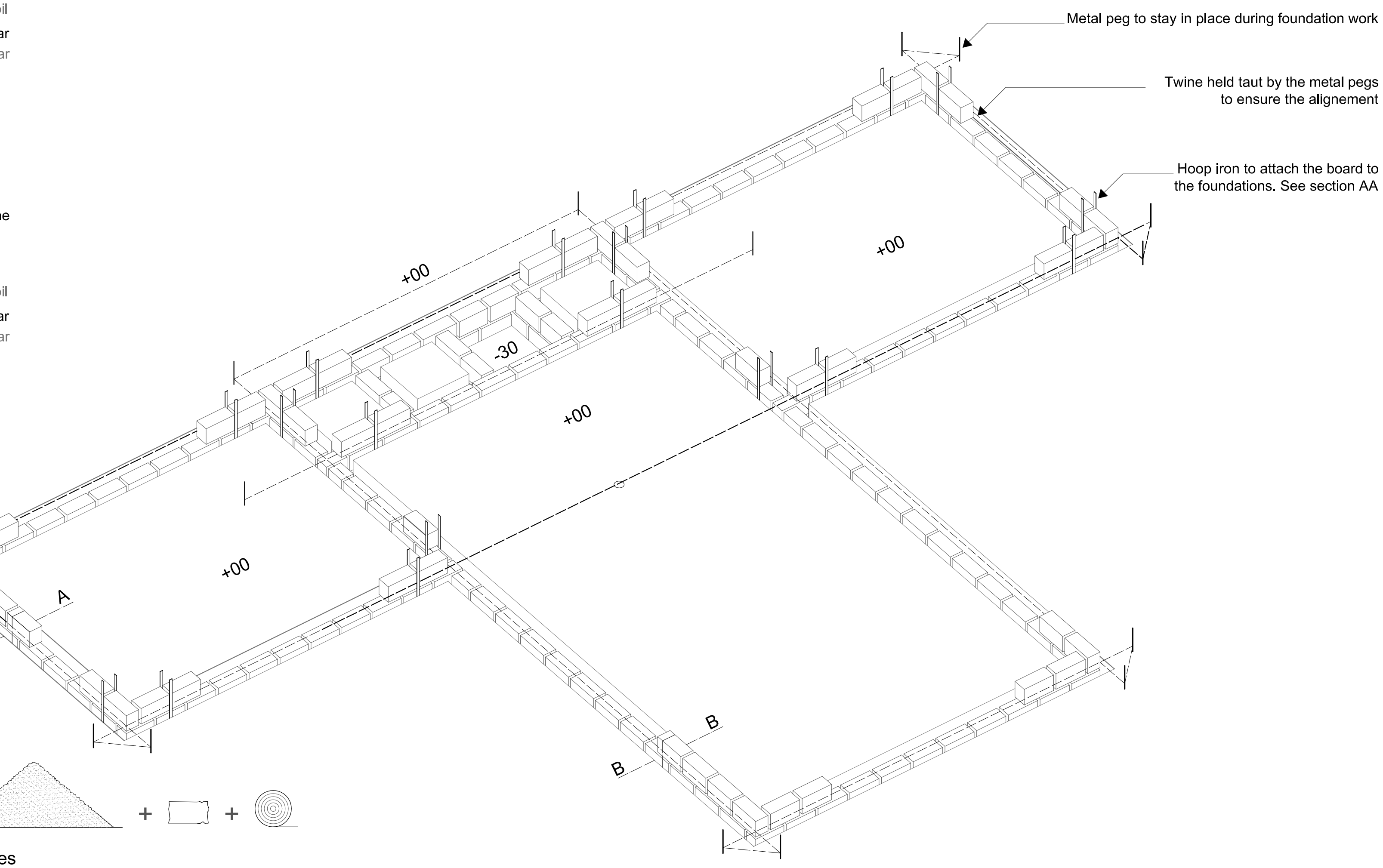


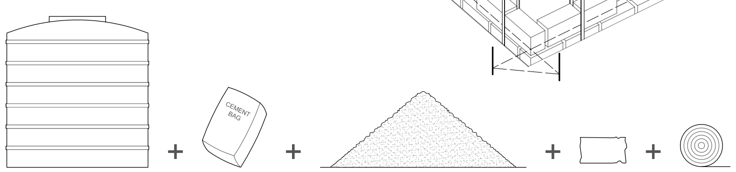
Section AA. Rooms. Stones + hoop-irons



Section BB. Terrace. Stone placement

Required tools

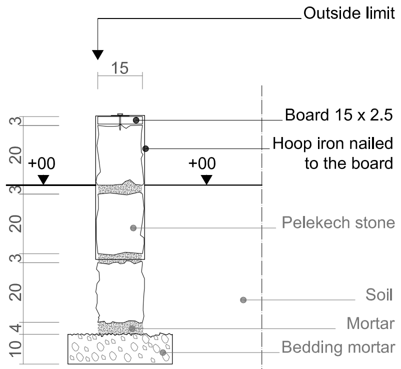




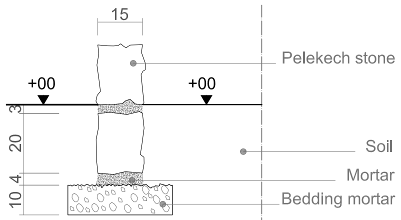
Required material for setting out the stones

Placing the stones

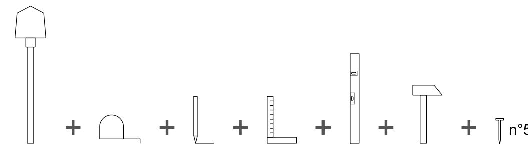
Foundations. 06



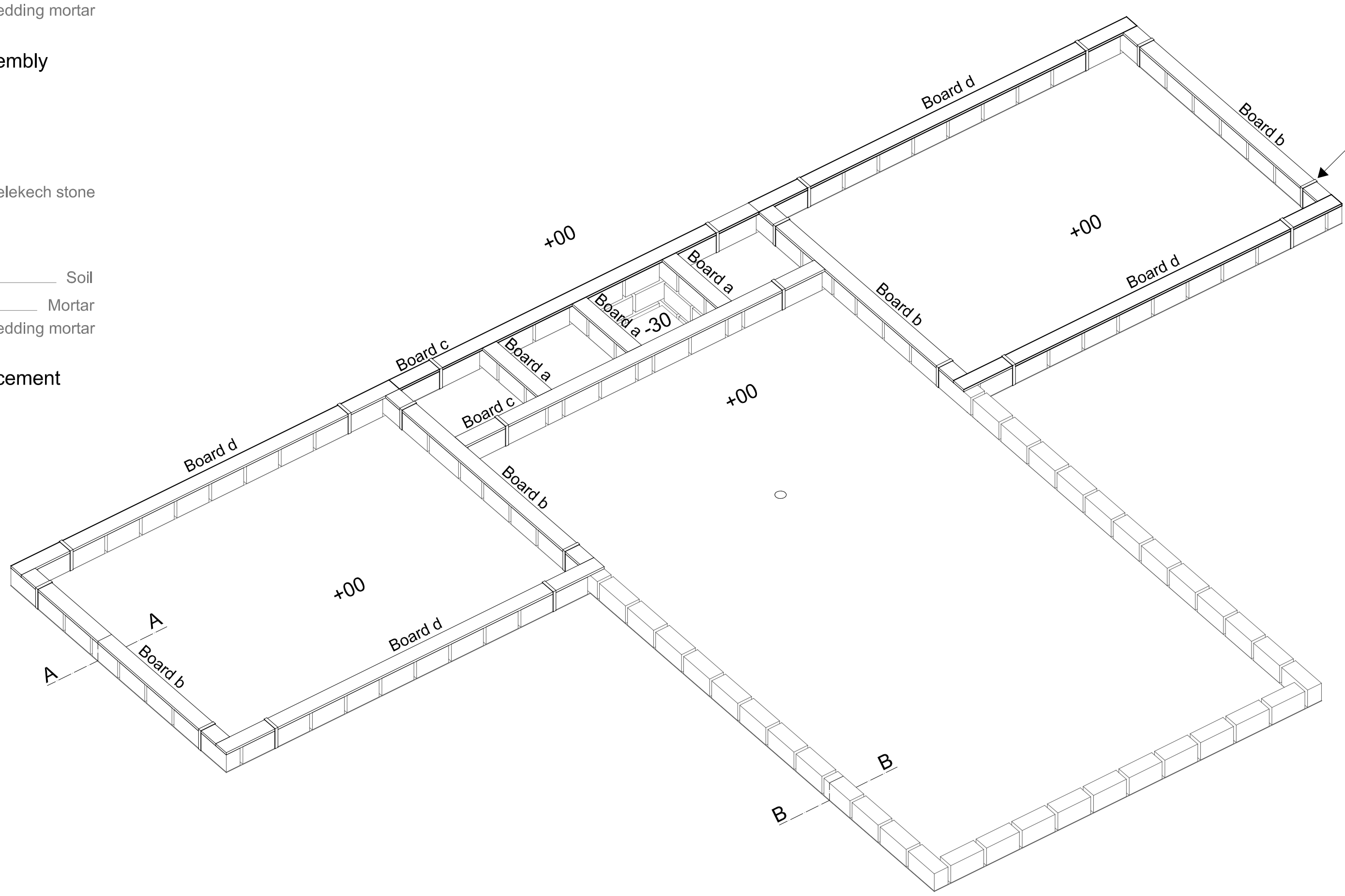
Section AA. Rooms. Board assembly

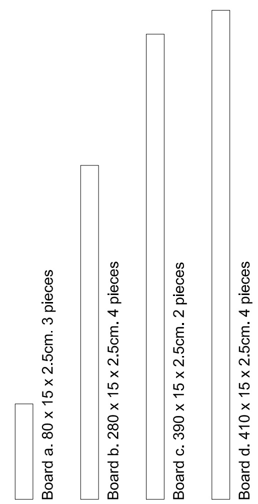


Section BB. Terrace. Stone placement



Required tools

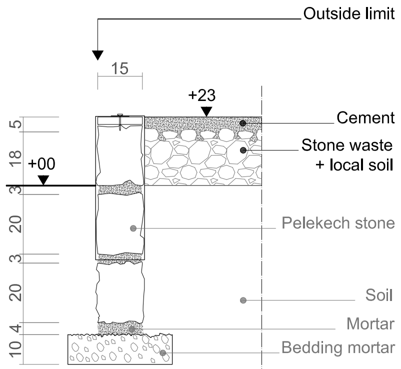




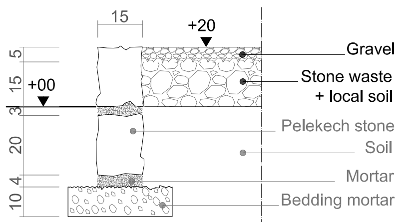
Required material

Placing the boards + nailing the hoop irons to the boards

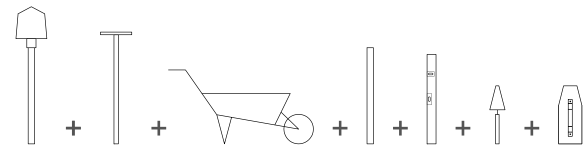
Foundations. 07



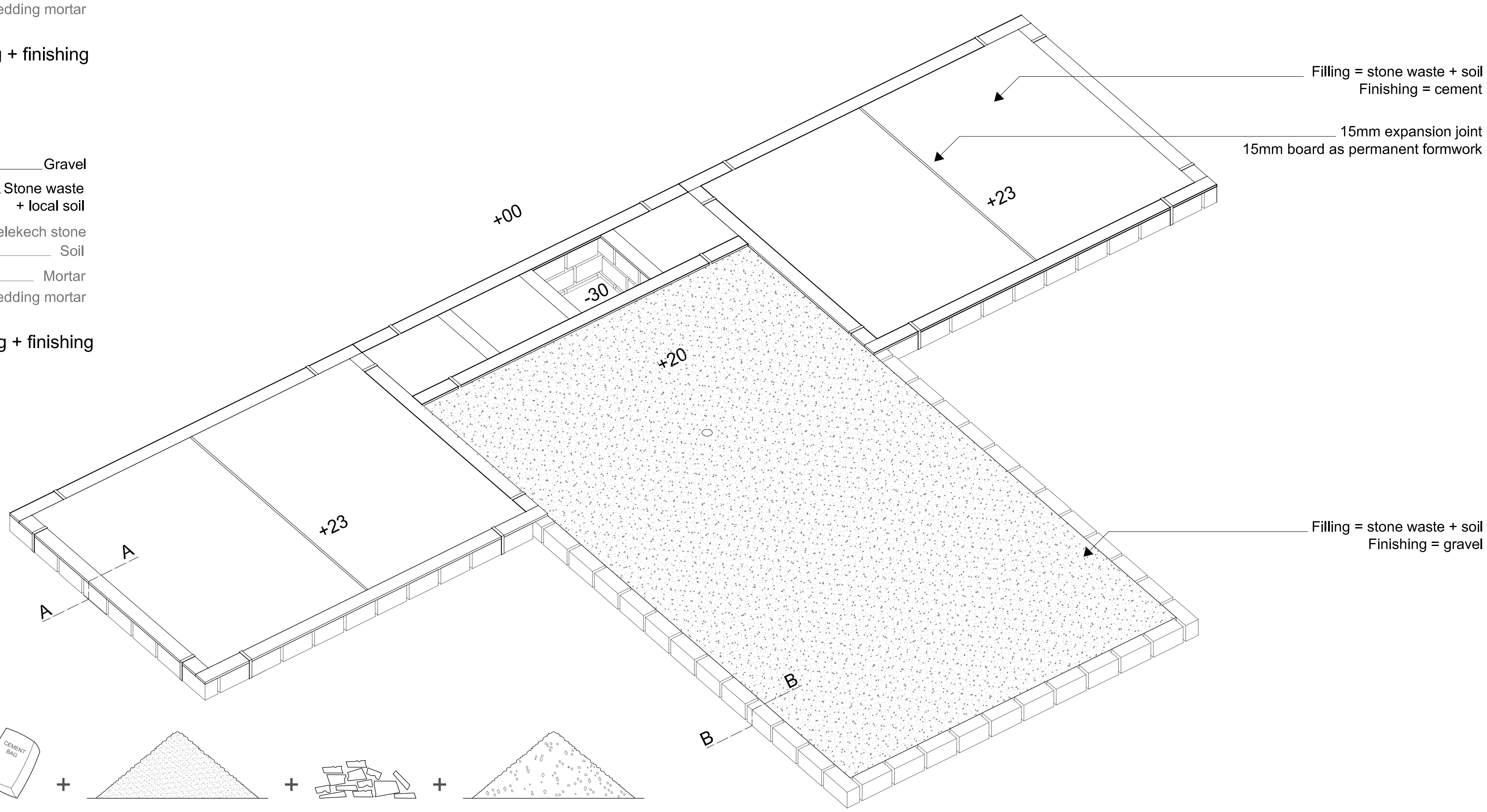
Section AA. Rooms. Floor filling + finishing



Section BB. Terrace. Floor filling + finishing

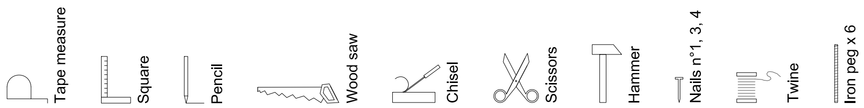


Required tools

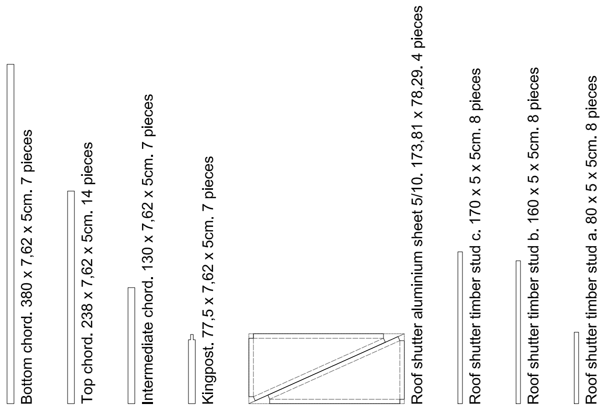


Required material for filling and finishing the floor

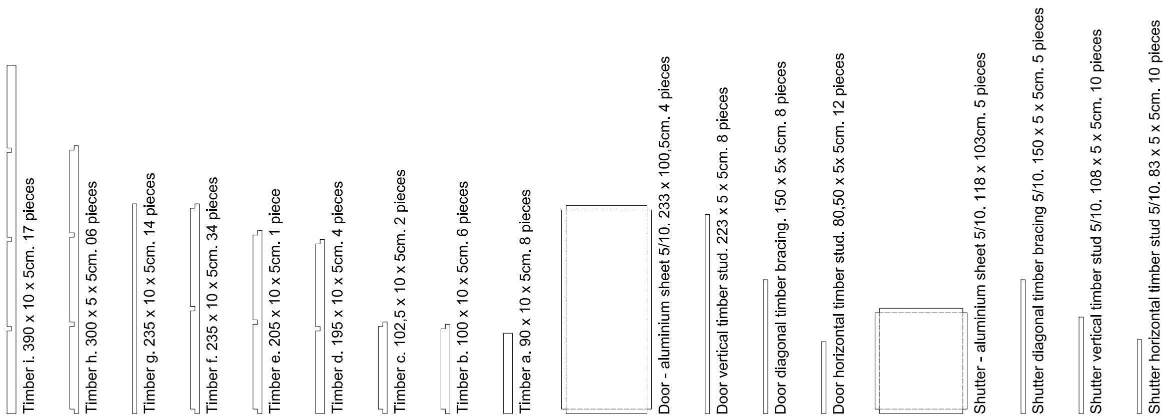
Carpentry



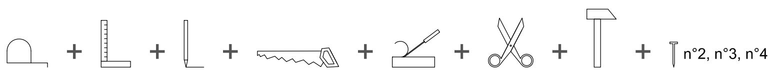
Tool inventory



Material inventory for trusses



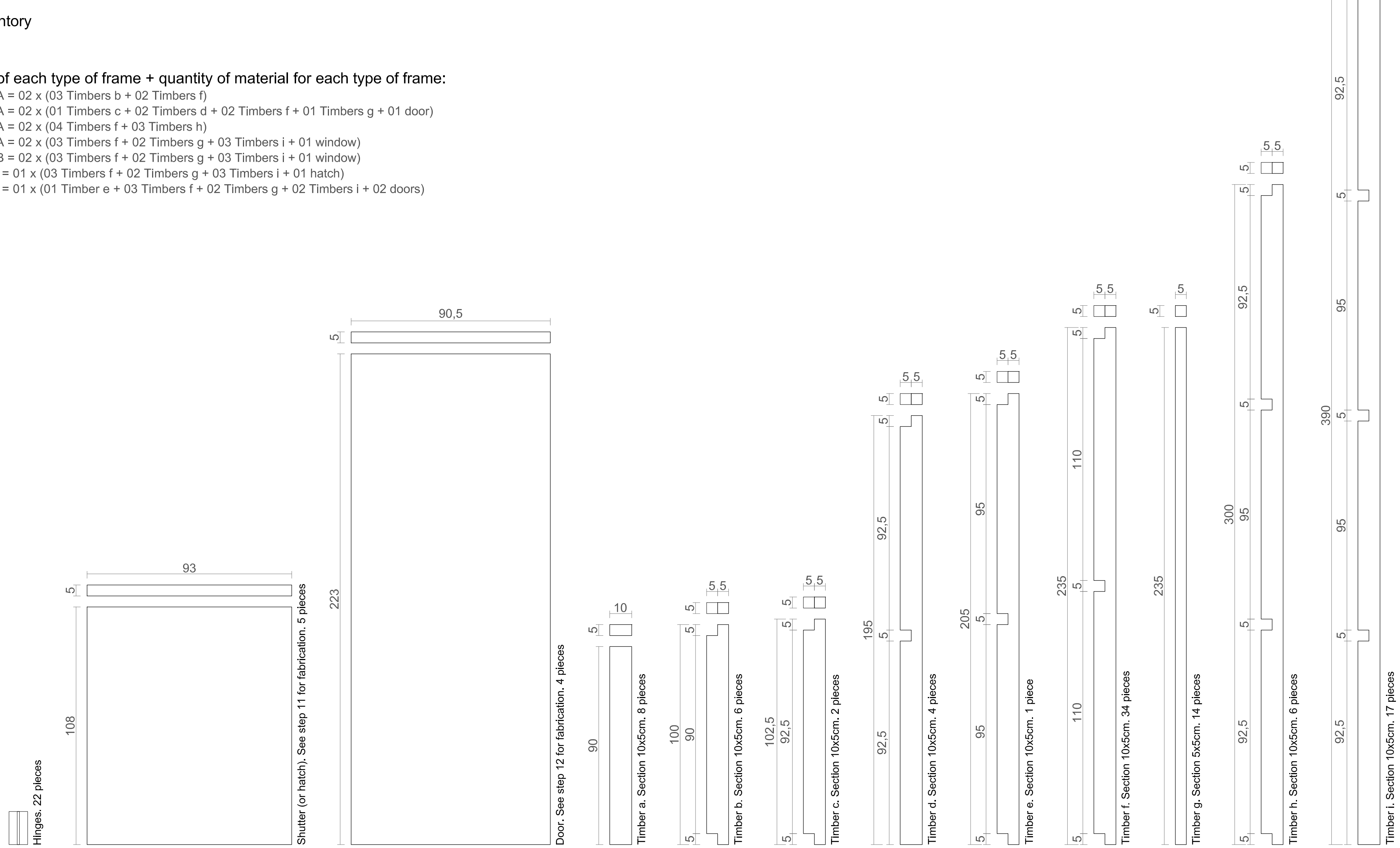
Material inventory for timber frames



Tool inventory

Quantity of each type of frame + quantity of material for each type of frame:

02 Types 1A = 02 x (03 Timbers b + 02 Timbers f)
02 Types 2A = 02 x (01 Timbers c + 02 Timbers d + 02 Timbers f + 01 Timbers g + 01 door)
02 Types 3A = 02 x (04 Timbers f + 03 Timbers h)
02 Types 4A = 02 x (03 Timbers f + 02 Timbers g + 03 Timbers i + 01 window)
02 Types 4B = 02 x (03 Timbers f + 02 Timbers g + 03 Timbers i + 01 window)
01 Type 4C = 01 x (03 Timbers f + 02 Timbers g + 03 Timbers i + 01 hatch)
01 Type 4D = 01 x (01 Timber e + 03 Timbers f + 02 Timbers g + 02 Timbers i + 02 doors)

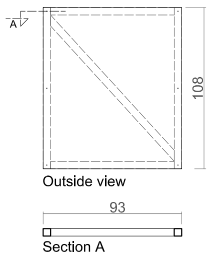


Material inventory

Preparation of the timber frames

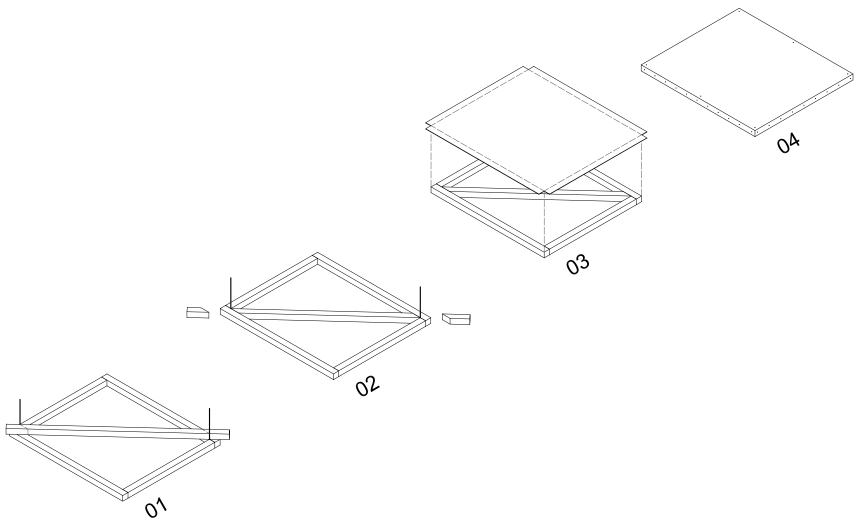
House B3 Manual

Carpentry. 10



Shutter (or hatch) dimensions

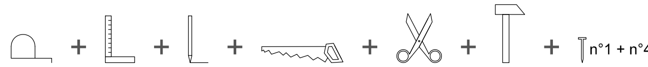
Attention: the dimensions are for the timber frames.
The thickness of the aluminium sheet, folded at the edges of the timber frame is taken into account for the timber fabrication



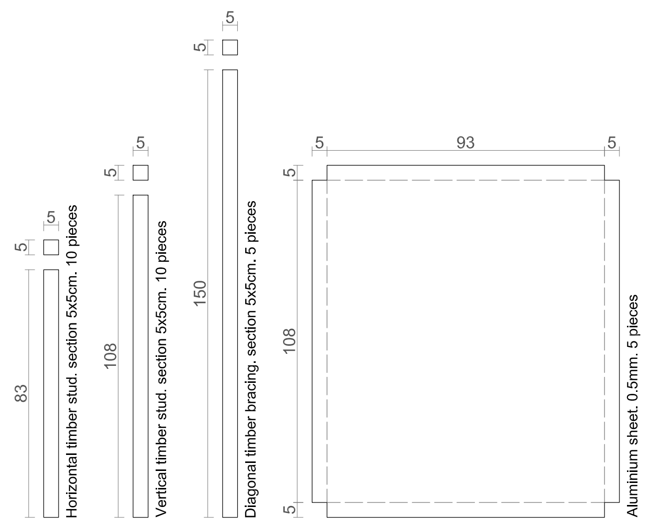
Shutter (or hatch) fabrication step-by-step

01. Nailing the frame + positioning the bracing
02. Cutting the bracing edges + nailing the bracing
03. Positioning the aluminium sheet
04. Folding and nailing the aluminium sheet on the sides of the timber frame

Fabrication of hatch and shutter. 1 hatch and 4 shutters

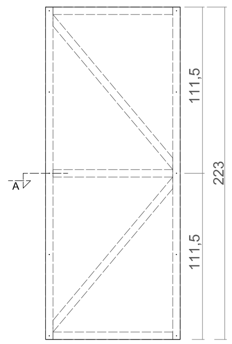


Required tools

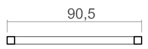


Required material for 5 panels

Carpentry. 11



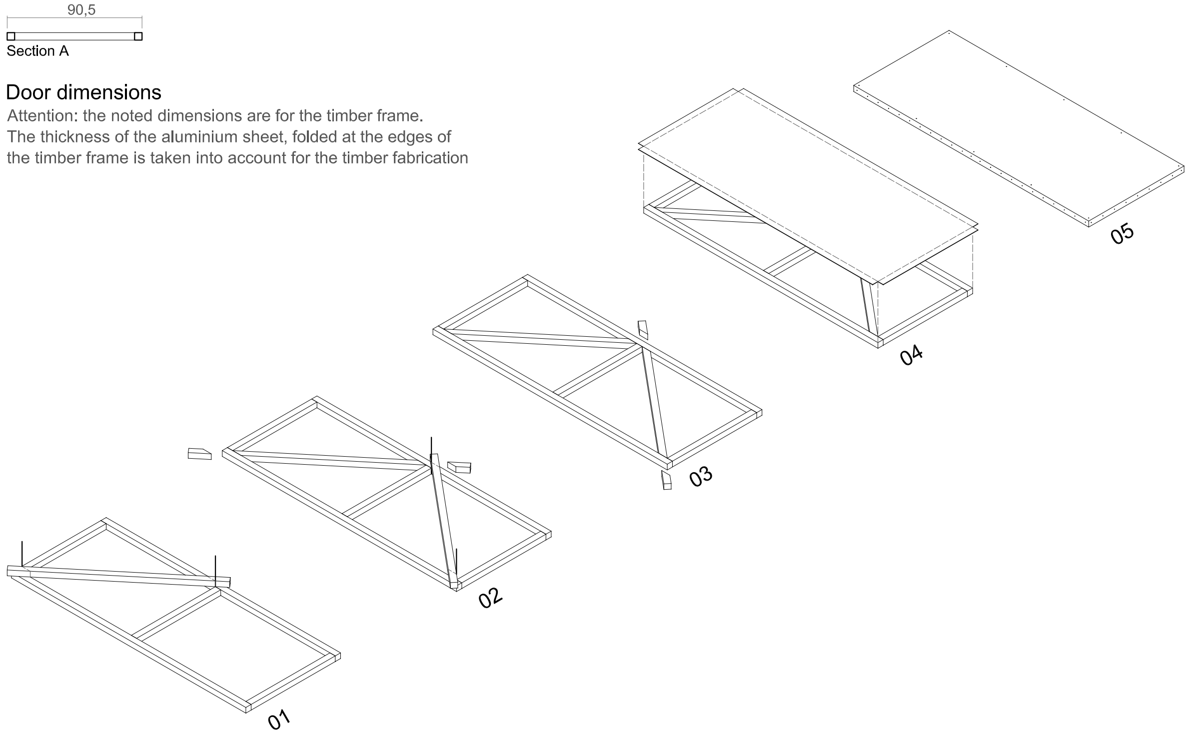
Outside view



Section A

Door dimensions

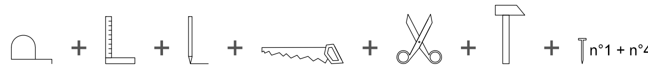
Attention: the noted dimensions are for the timber frame.
The thickness of the aluminium sheet, folded at the edges of
the timber frame is taken into account for the timber fabrication



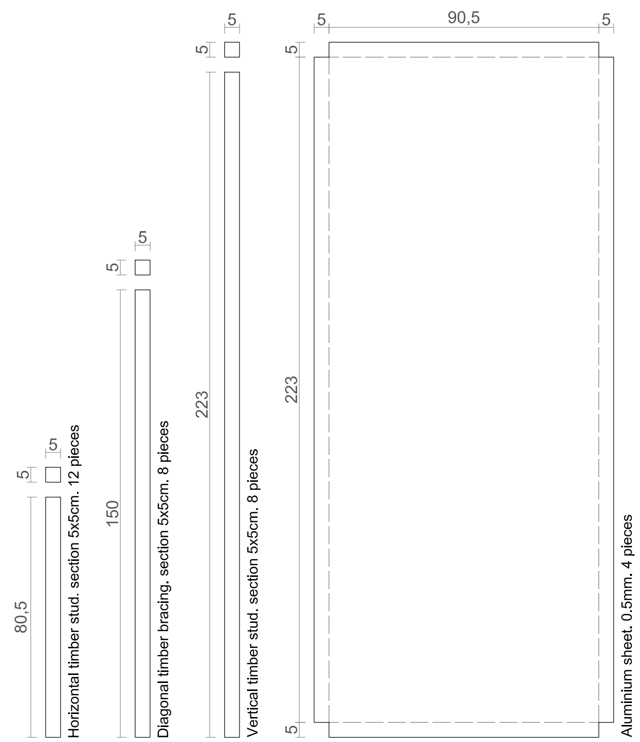
Door fabrication step-by-step

01. Nailing the frame + positioning the top bracing
02. Cutting the top bracing edges + nailing the top bracing + positioning the bottom bracing
03. Cutting the bottom bracing edges + nailing the bottom bracing
04. Positioning the aluminium sheet
05. Folding and nailing the aluminium sheet on the sides of the timber frame

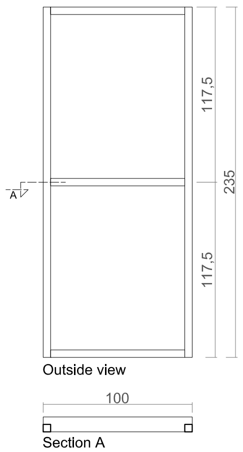
Fabrication of doors. 4 panels



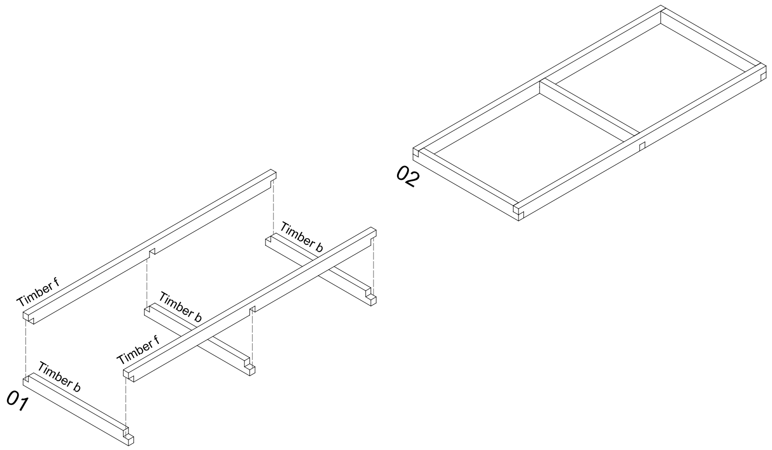
Required tools



Required material for 4 panels



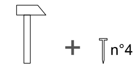
Frame 1A dimensions



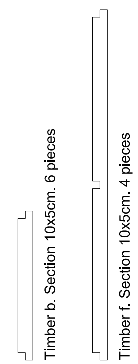
Frame 1A fabrication step-by-step

01. Assembly of timber profiles
02. Nailing of timber profiles. Completion of Type 1A

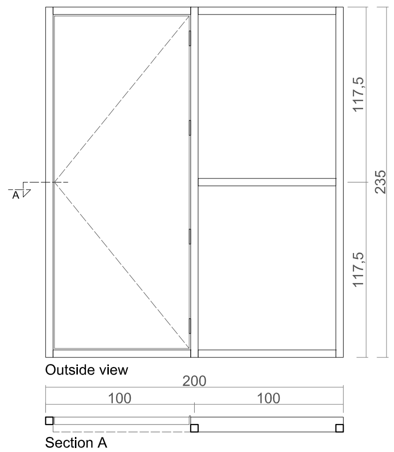
Fabrication of timber frames type 1A. 2 panels 100cm x 235cm



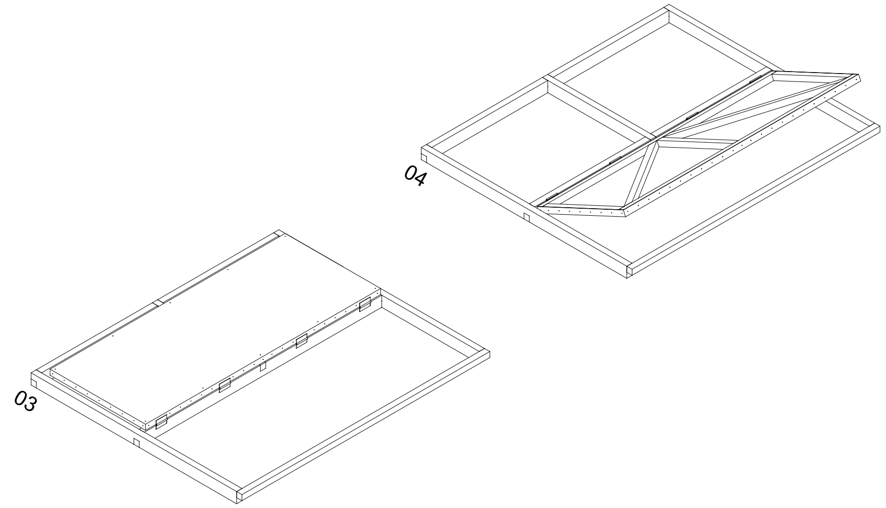
Required tools

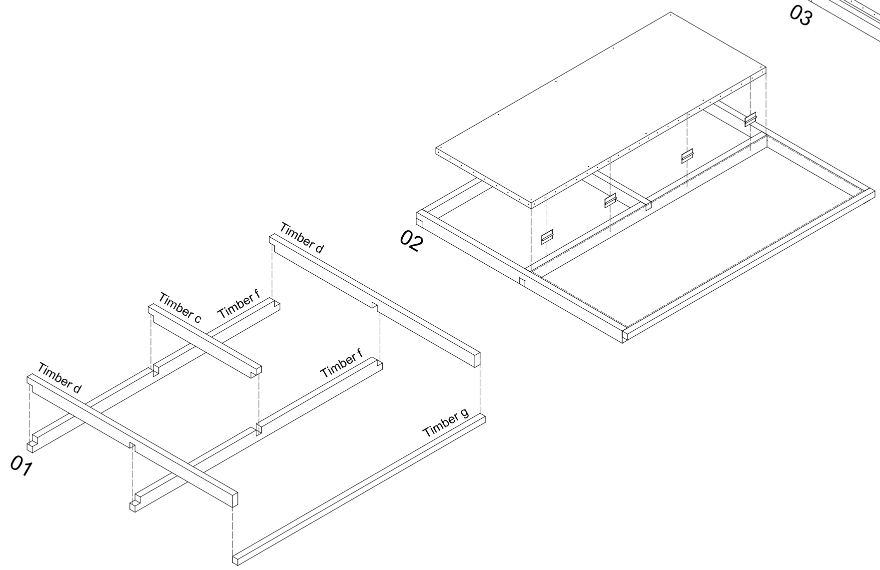


Required material for 2 panels



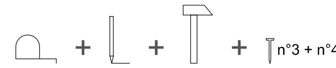
Frame 2A dimensions



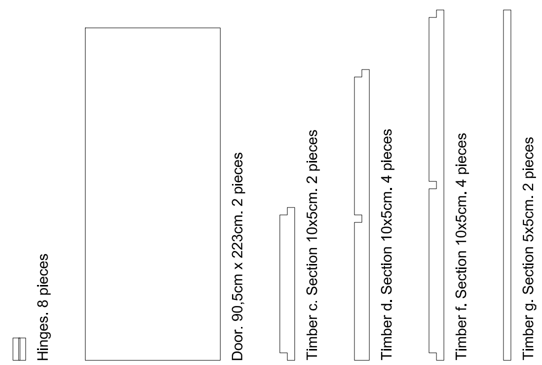


Frame 2A fabrication step-by-step

01. Assembly of timber profiles
02. Nailing the timber profiles + positioning the door
03. Nailing the door in opened position
04. Rotation of the door from opened to closed position. Completion of Type 2A
Attention: the axonometric view shows the inside face of the timber frame

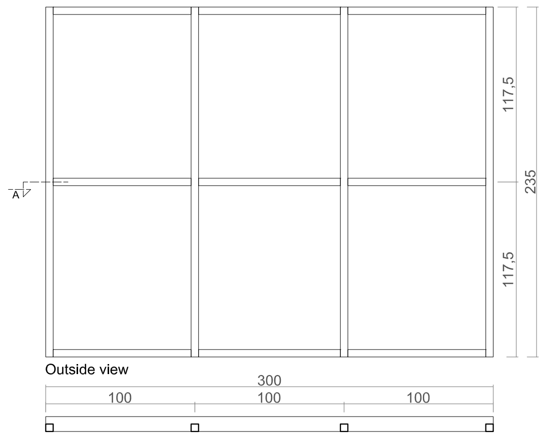


Required tools

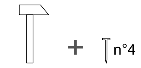


Required material for 2 panels

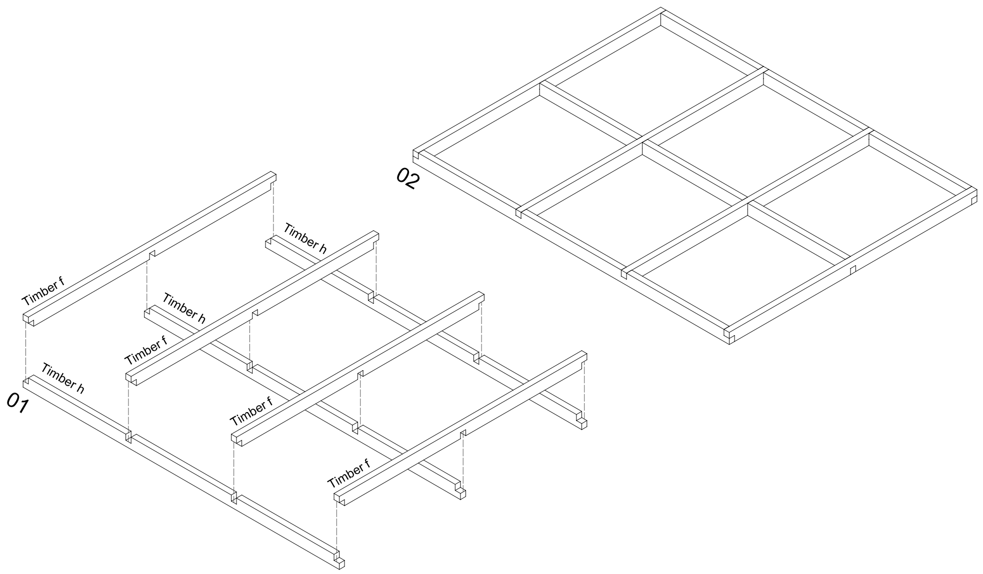
Fabrication of timber frames type 2A. 2 panels 200cm x 235cm



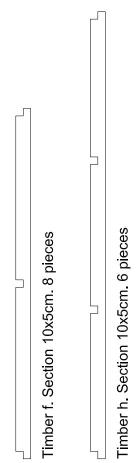
Frame 3A dimensions



Required tools

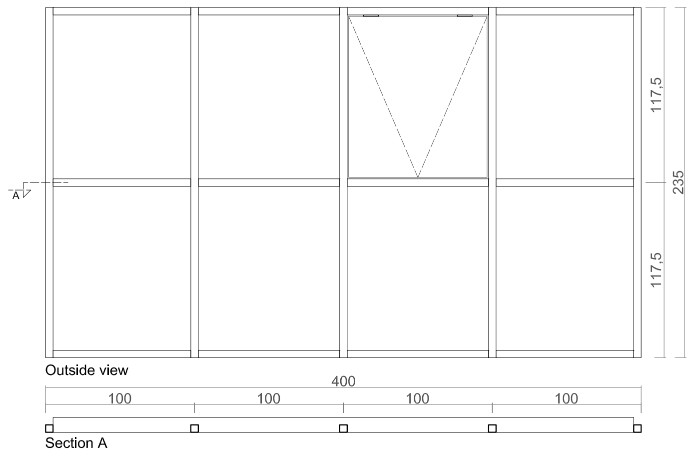


Frame 3A fabrication step-by-step
01. Assembly of timber profiles
02. Nailing the timber profiles. Completion of Type 3A

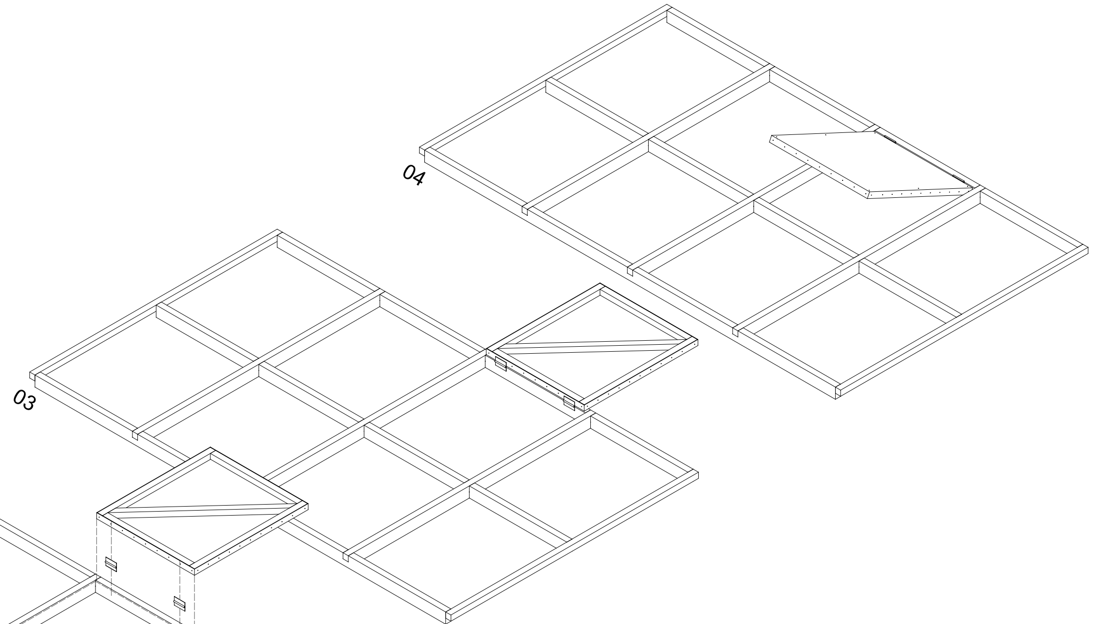


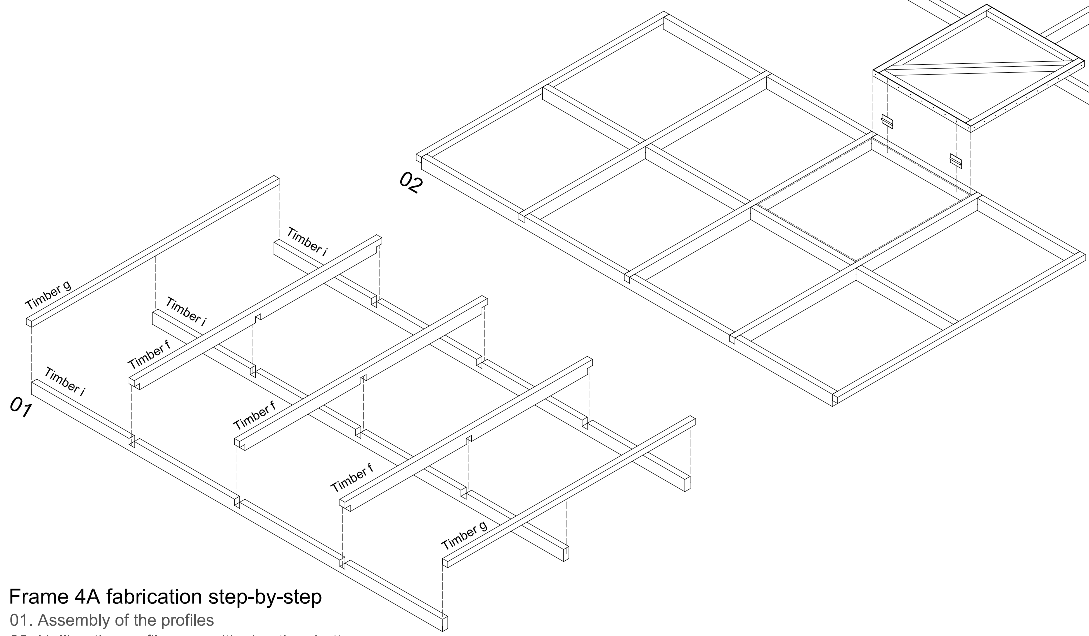
Required material for 2 panels

Fabrication of timber frames type 3A. 2 panels 300cm x 235cm



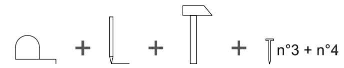
Frame 4A dimensions



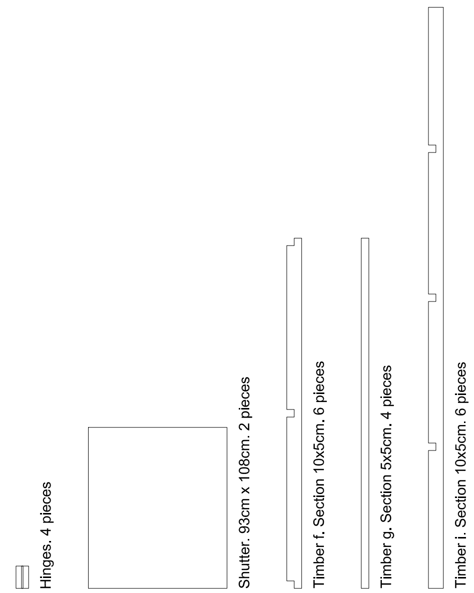


Frame 4A fabrication step-by-step

01. Assembly of the profiles
02. Nailing the profiles + positioning the shutter
03. Nailing the shutter in opened position
04. Rotation of the shutter from opened to closed position. Completion of Type 4A

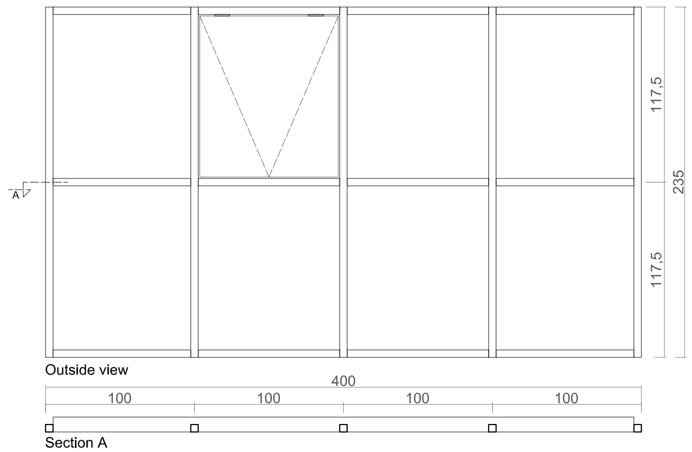


Required tools

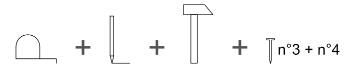


Required material for 2 panels

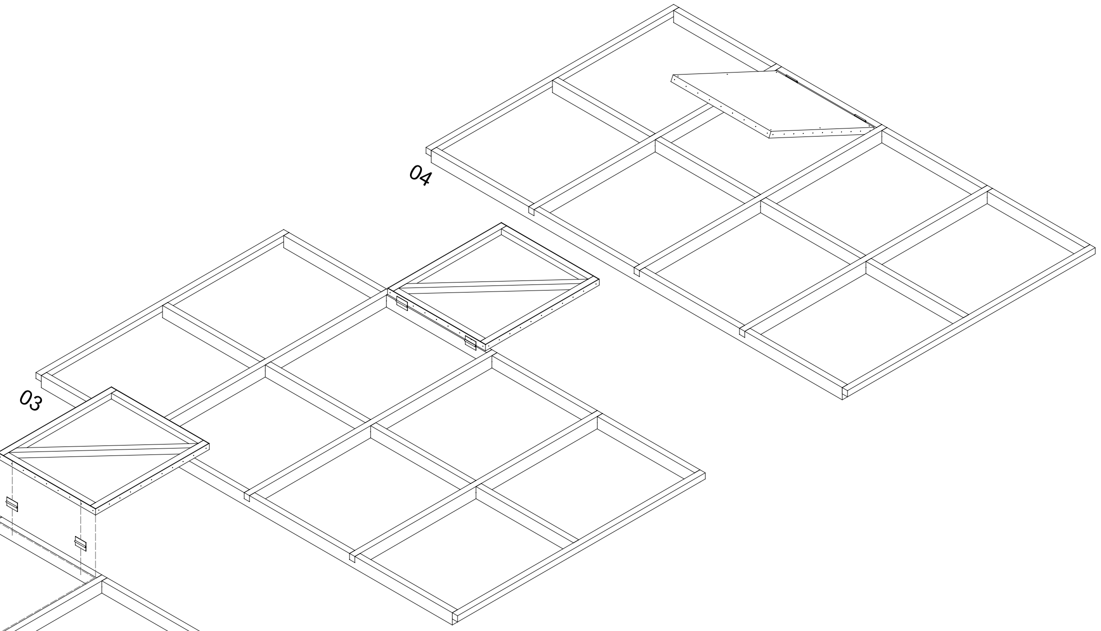
Fabrication of timber frames type 4A. 2 panels 400cm x 235cm

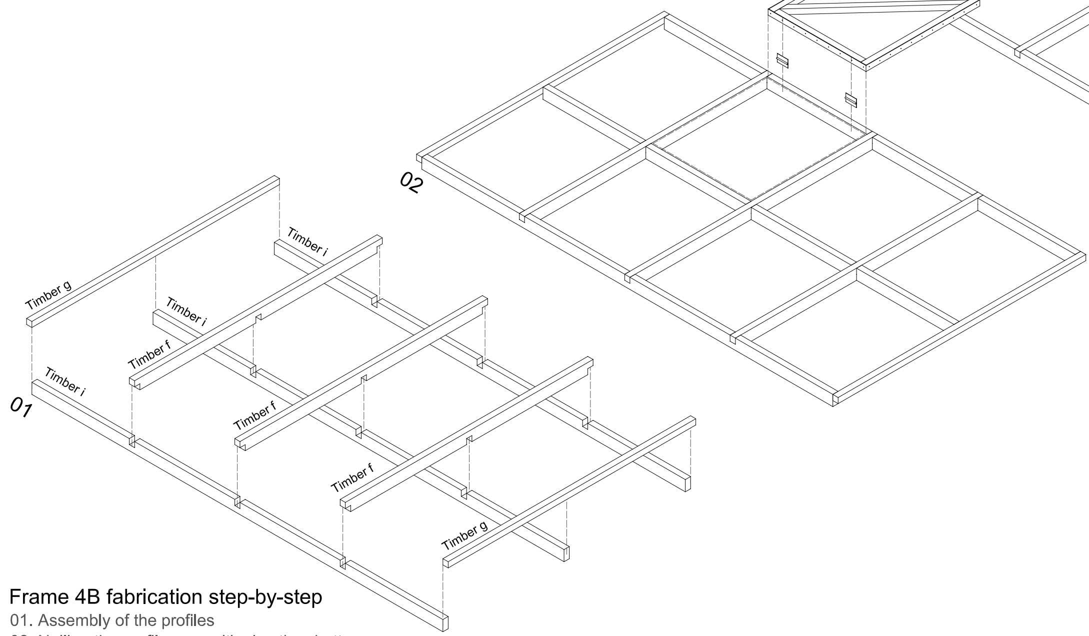


Frame 4B dimensions



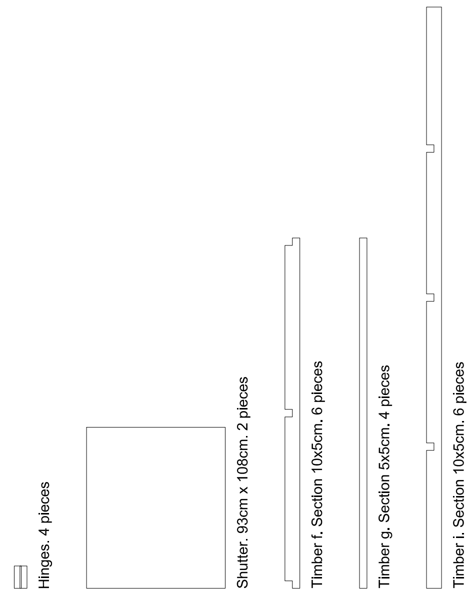
Required tools





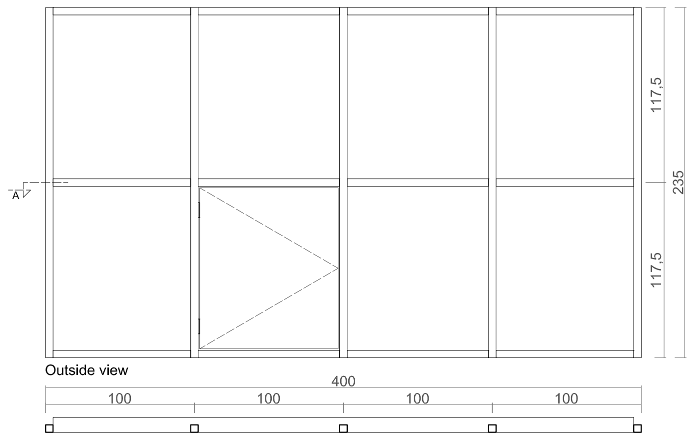
Frame 4B fabrication step-by-step

01. Assembly of the profiles
02. Nailing the profiles + positioning the shutter
03. Nailing the shutter in opened position
04. Rotation of the shutter from opened to closed position. Completion of Type 4B

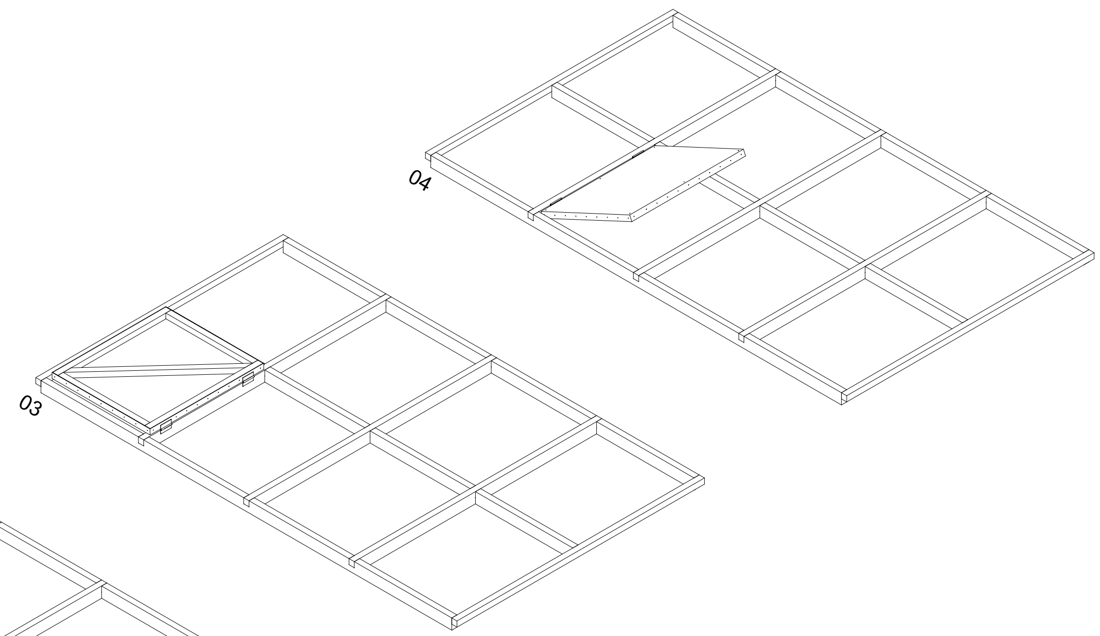


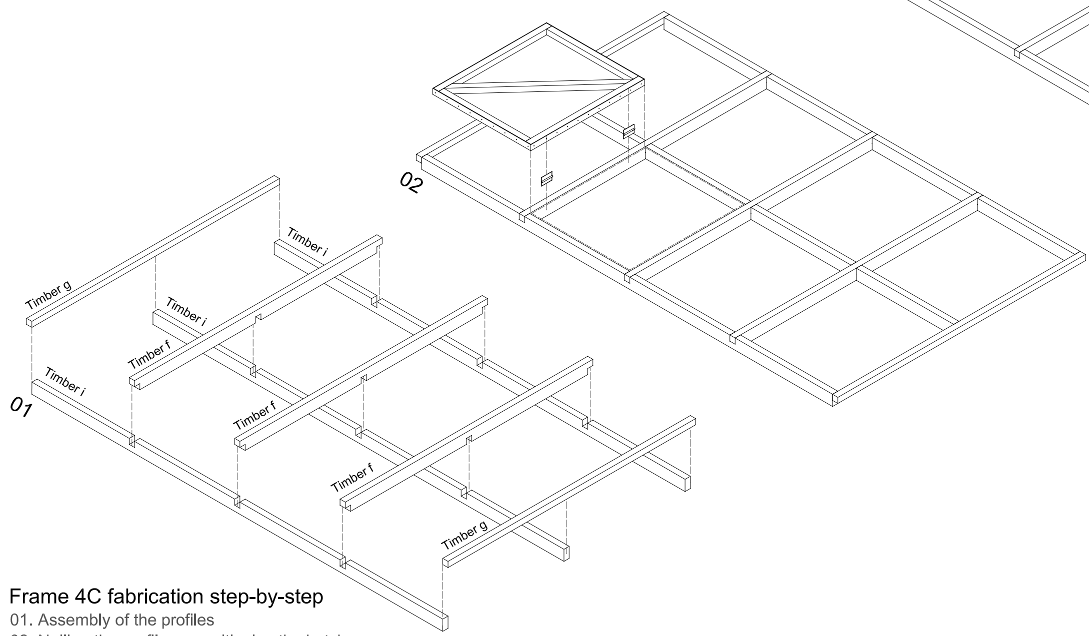
Required material for 2 panels

Fabrication of timber frames type 4B. 2 panels 400cm x 235cm



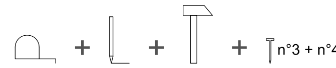
Frame 4C dimensions



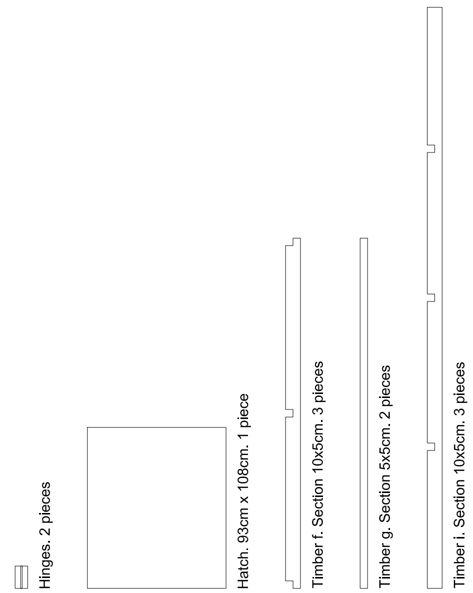


Frame 4C fabrication step-by-step

01. Assembly of the profiles
02. Nailing the profiles + positioning the hatch
03. Nailing the hatch in opened position
04. Rotation of the hatch from opened to closed position. Completion of Type 4C

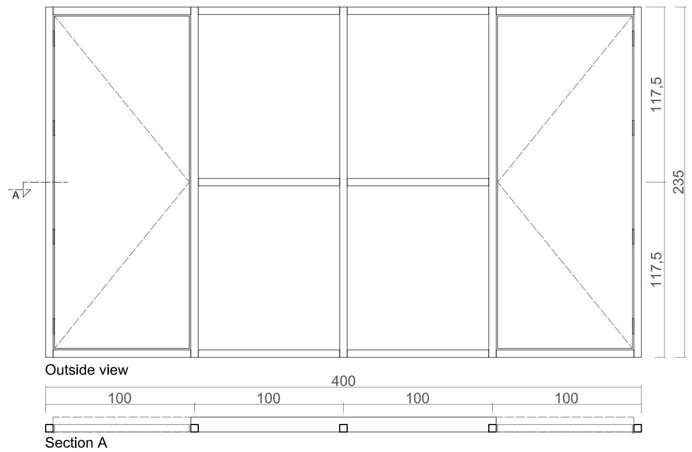


Required tools

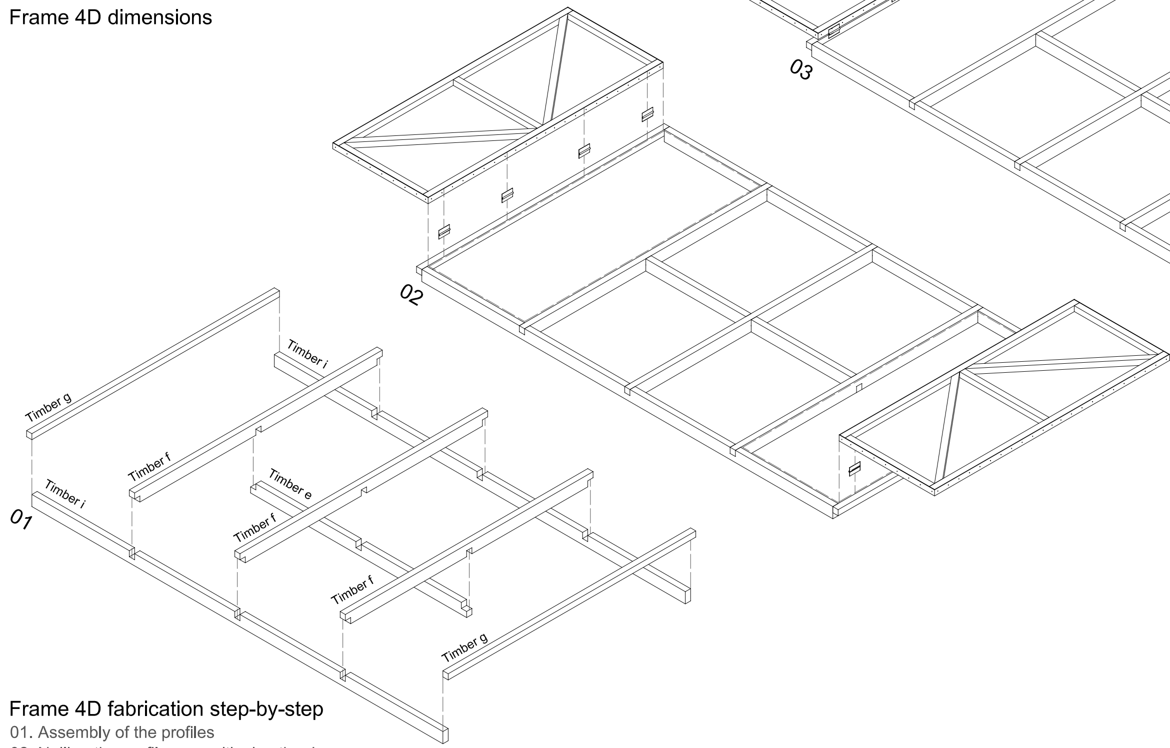


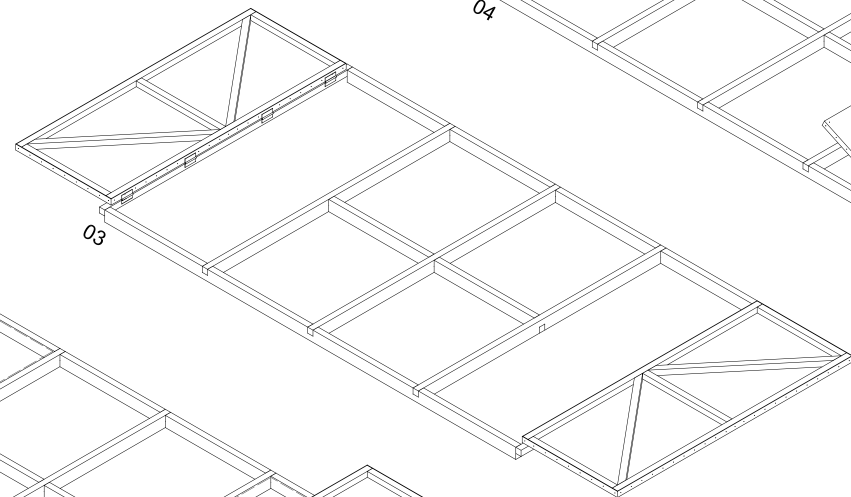
Required material for 1 panel

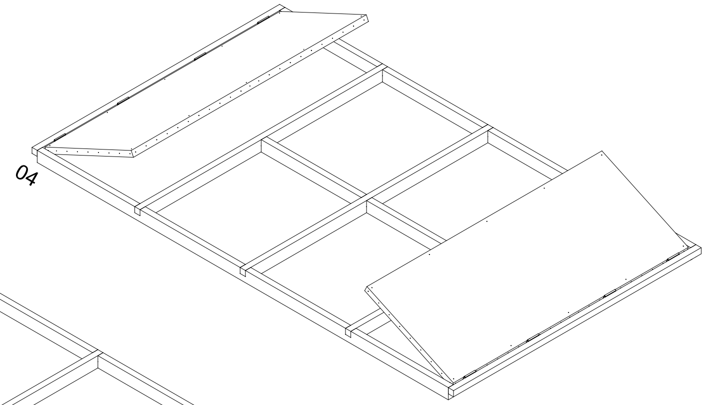
Fabrication of timber frame type 4C. 1 panel 400cm x 235cm



Frame 4D dimensions

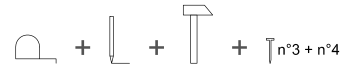




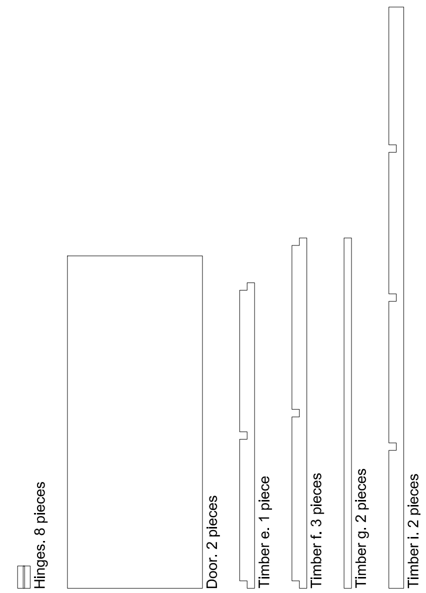


Frame 4D fabrication step-by-step

01. Assembly of the profiles
02. Nailing the profiles + positioning the doors
03. Nailing the doors in opened position
04. Rotation of the doors from opened to closed position. Completion of Type 4D



Required tools



Required material for 1 panel

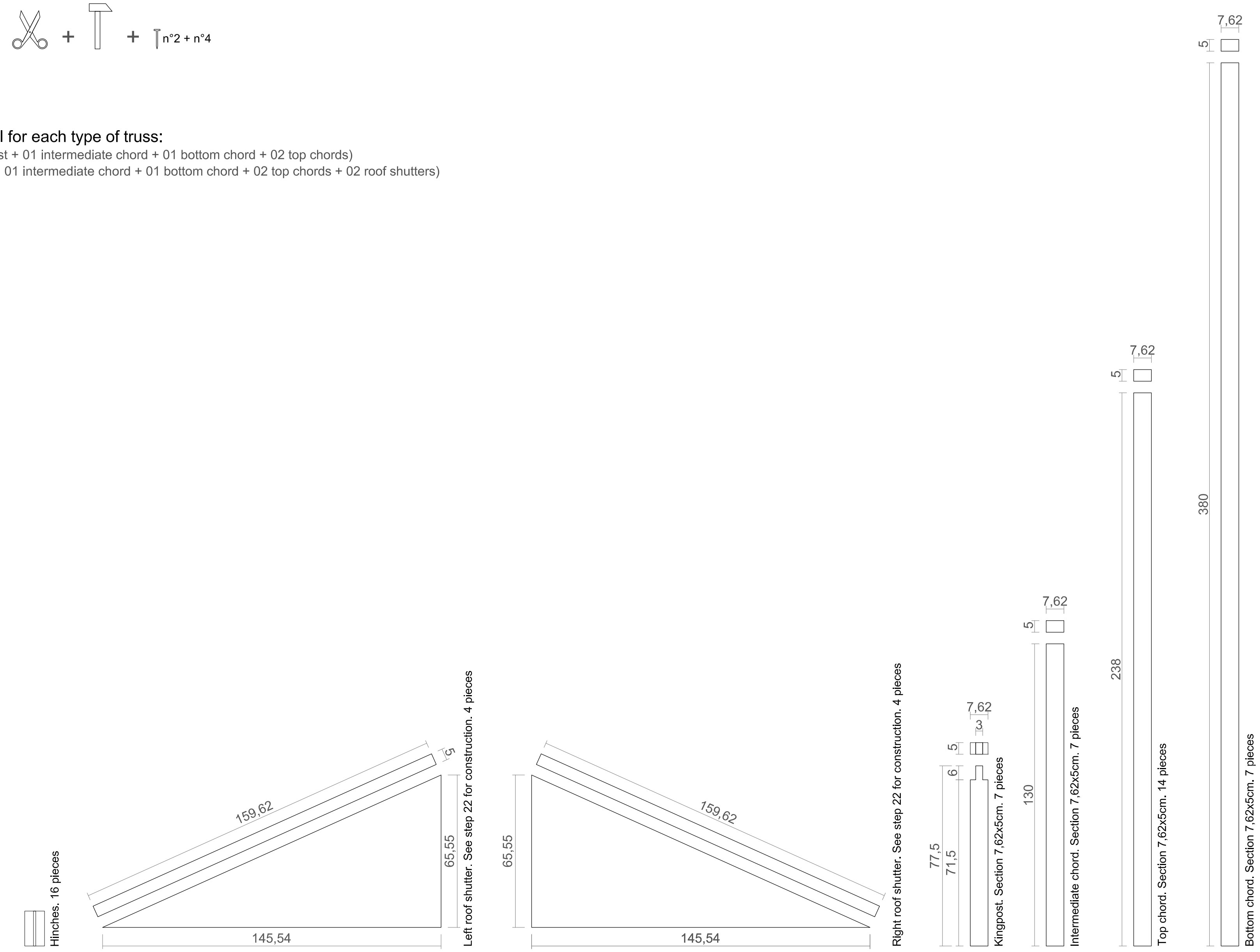
Fabrication of timber frame type 4D. 1 panel 400cm x 235cm

Tool inventory

Quantity of trusses + quantity of material for each type of truss:

03 trusses without roof shutters = 03 x (01 kingpost + 01 intermediate chord + 01 bottom chord + 02 top chords)

04 trusses with roof shutters = 04 x (01 kingpost + 01 intermediate chord + 01 bottom chord + 02 top chords + 02 roof shutters)

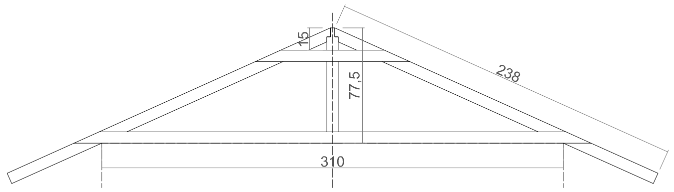


Material inventory

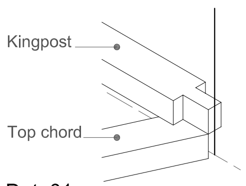
House B3 Manual

Carpentry. 20

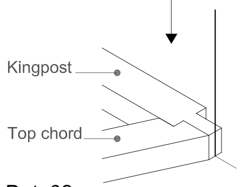
Preparation of the roof trusses



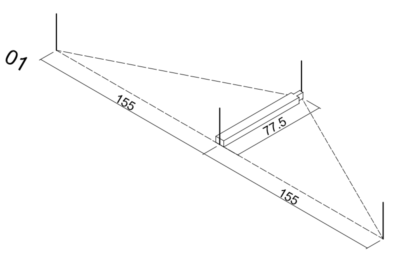
Truss dimensions
Height of the kingpost = 1/4 of the width of the house

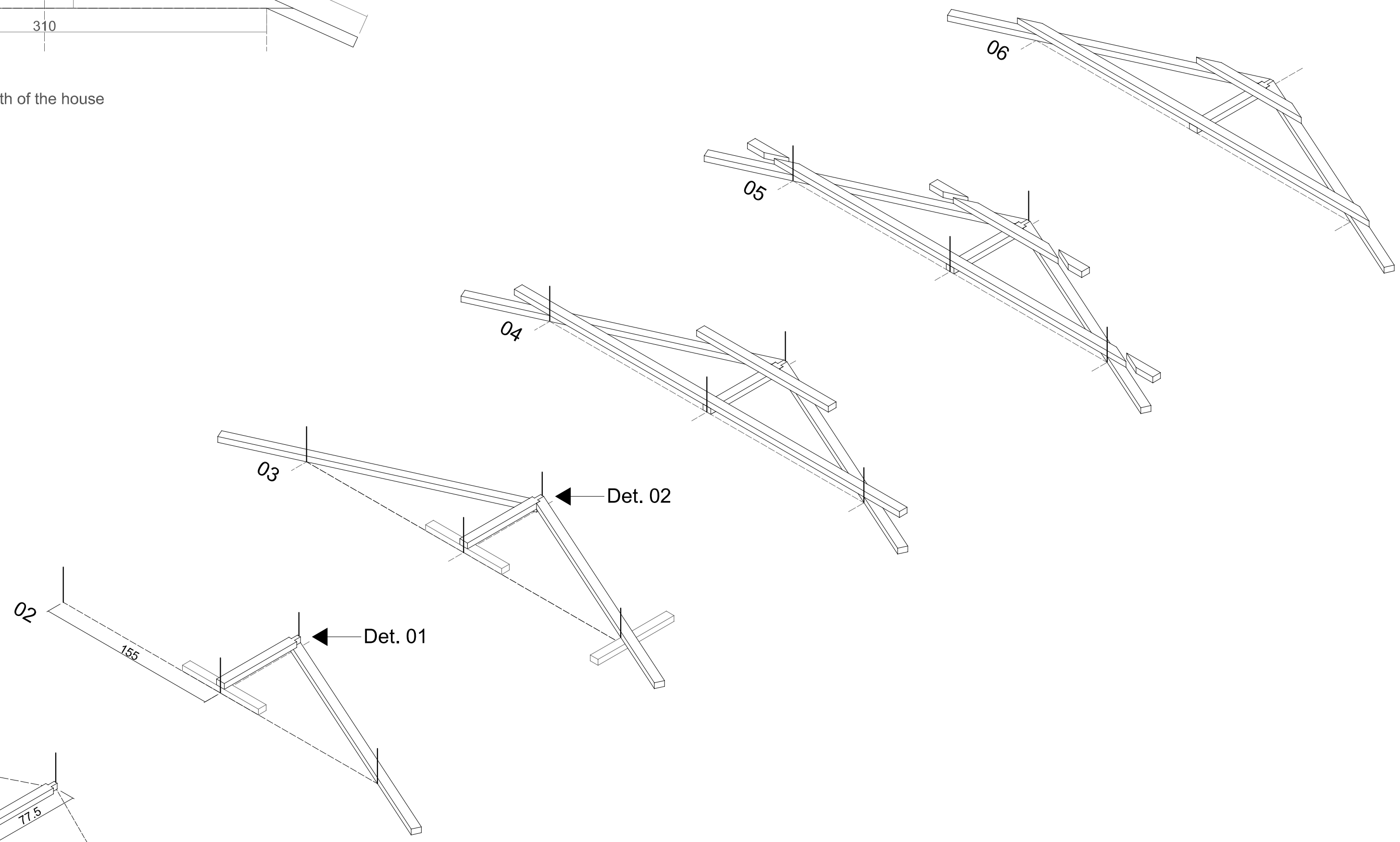


Det. 01
Tracing the top chord edge



Det. 02
Nailing the kingpost + the top chord

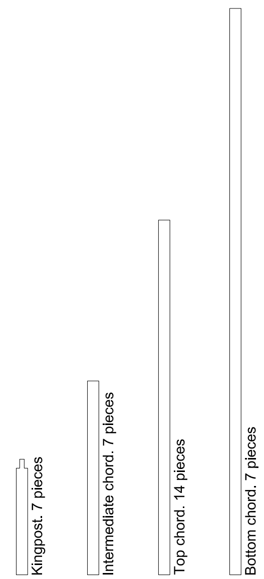




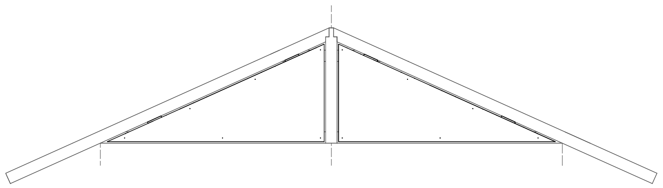
Truss fabrication step-by-step
01. Positioning the kingpost
02. Positioning the top chord
03. Nailing the kingpost/top chord + positioning the second top chord
04. Positioning the bottom and intermediate chords
05. Cutting the bottom and intermediate chord edges.
06. Truss completed

Fabrication of 7 trusses

Required tools



Required material for 7 trusses

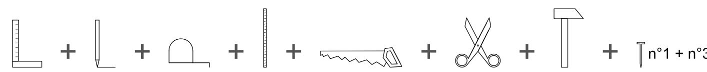


View of the roof shutters. Closed position

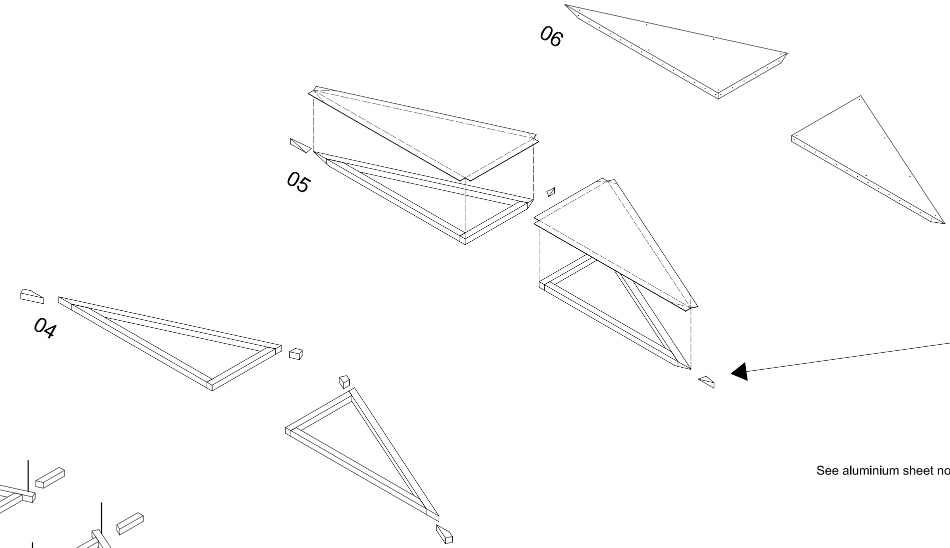
Shutter external dimensions: 65,55cm x 145,54cm x159,62cm

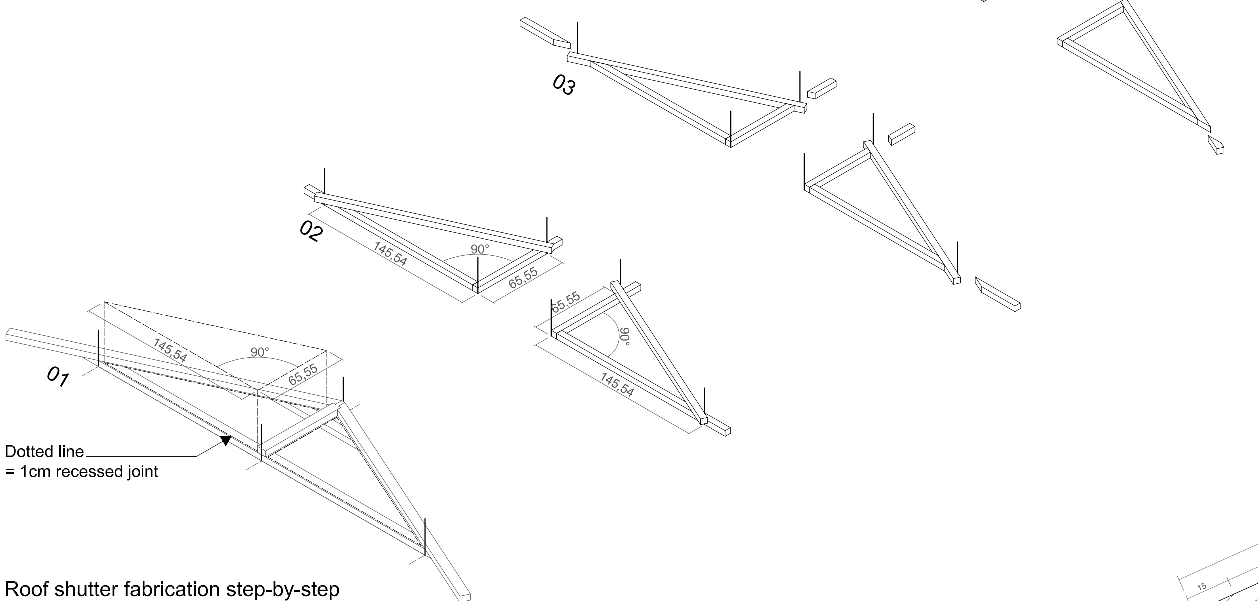
From step 05 to step 06

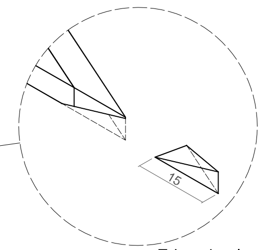
1. Shaping the bottom edges of the timber stud c
to ensure the opening of the shutters
2. Folding the aluminium sheets on the timber frames
3. Nailing the aluminium sheets on the sides of the timber frames
to ensure nails are invisible when shutters are in the closed position
4. Trimming excess aluminium pieces



Required tools





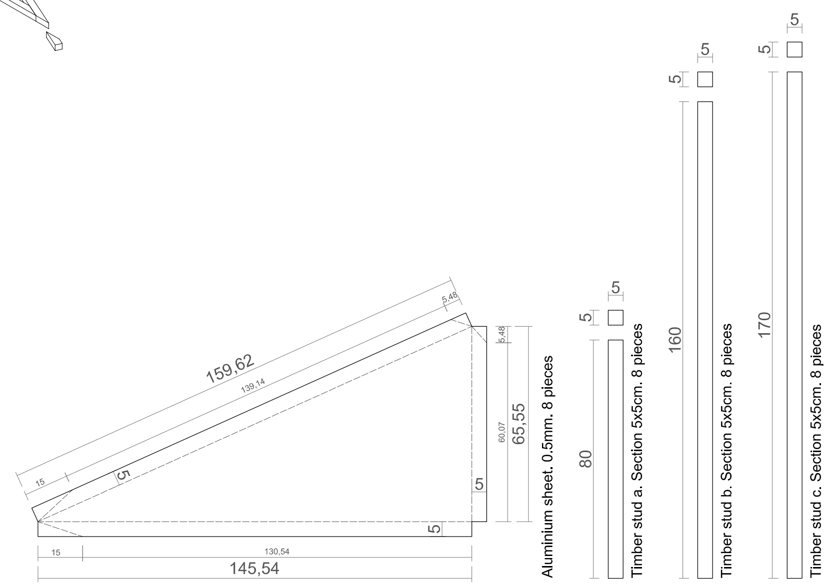


Edge shaping

See aluminium sheet notation (above) for the measures of the 2 corners

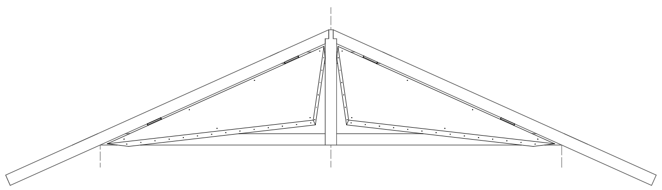
Roof shutter fabrication step-by-step

01. Tracing the outside limit of the shutters
02. Nailing a+b and positioning c
03. Cutting a+b edges and nailing c
04. Cutting c edges
05. Shaping c edges and positioning of aluminium sheets
06. Folding and nailing the aluminium sheet to the sides of the timber frame

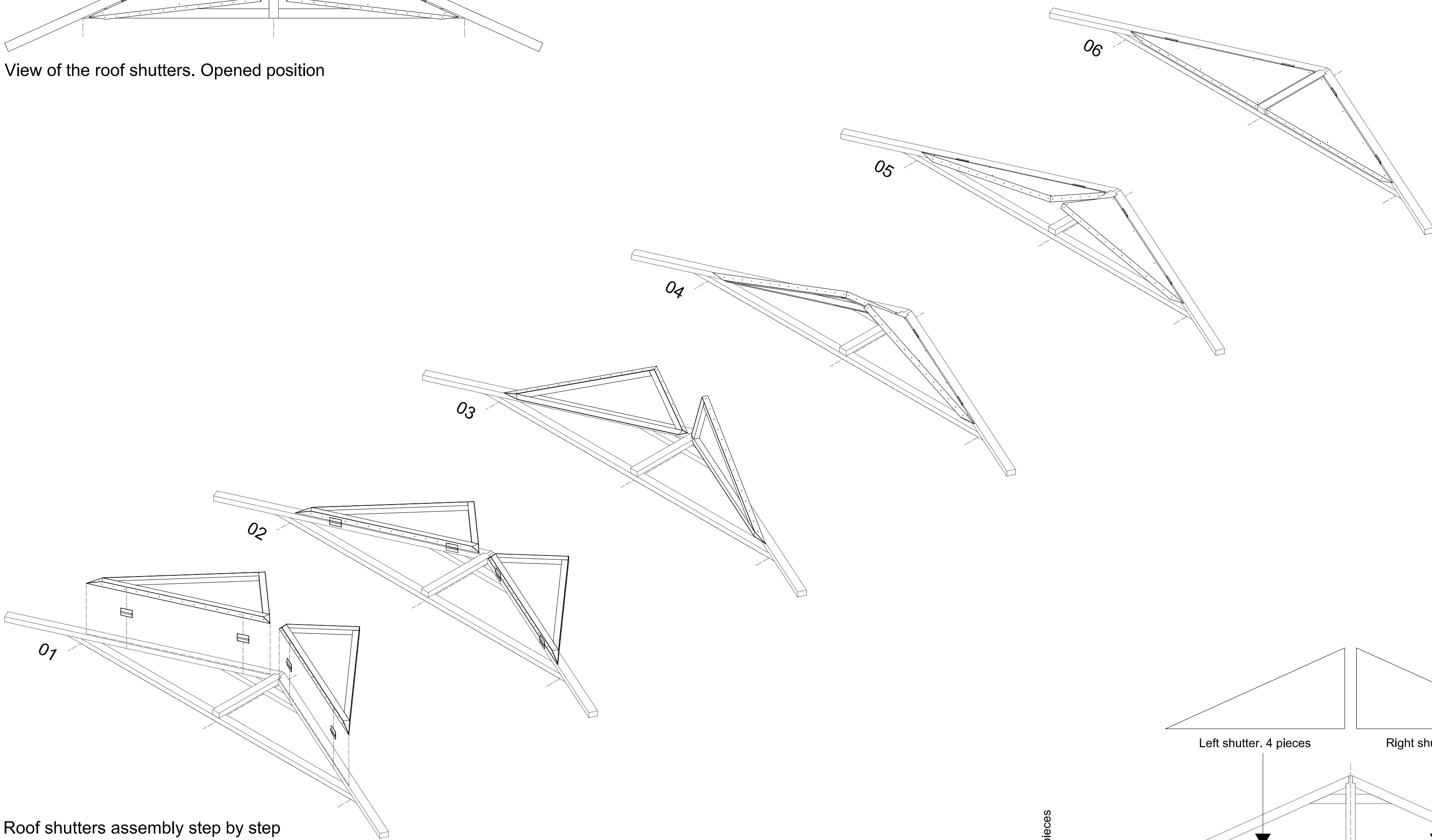


Required material for 8 roof shutters

Fabrication of the roof shutters (4 left +4 right)

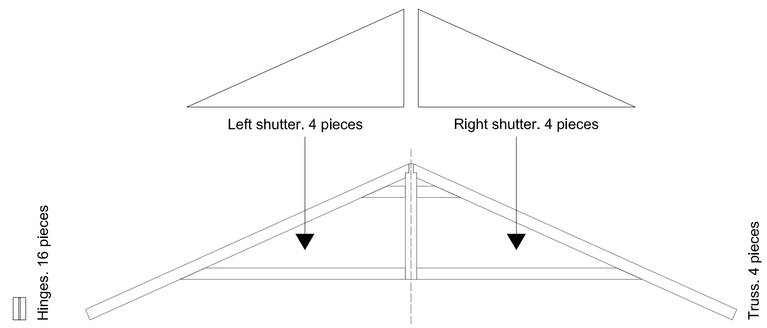


View of the roof shutters. Opened position



Roof shutters assembly step by step
01. Positioning the shutters
02. Nailing the shutters in 180° position
03. View of the shutters in 90° position
04. View of the shutters in 45° position
05. View of the shutters in 25° position
06. View of the shutters in closed position. Sand storm conditions

Required tools

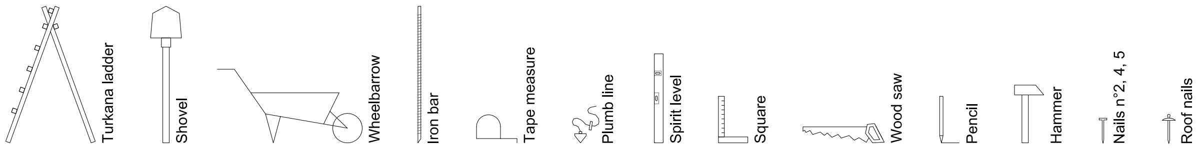


Required material for the 4 trusses with shutters

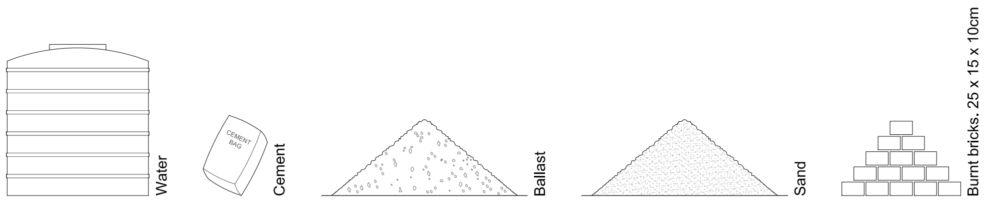
Assembly of the roof shutters into 4 trusses

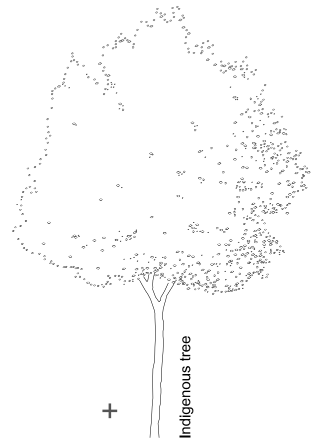
Carpentry. 23

Assembly

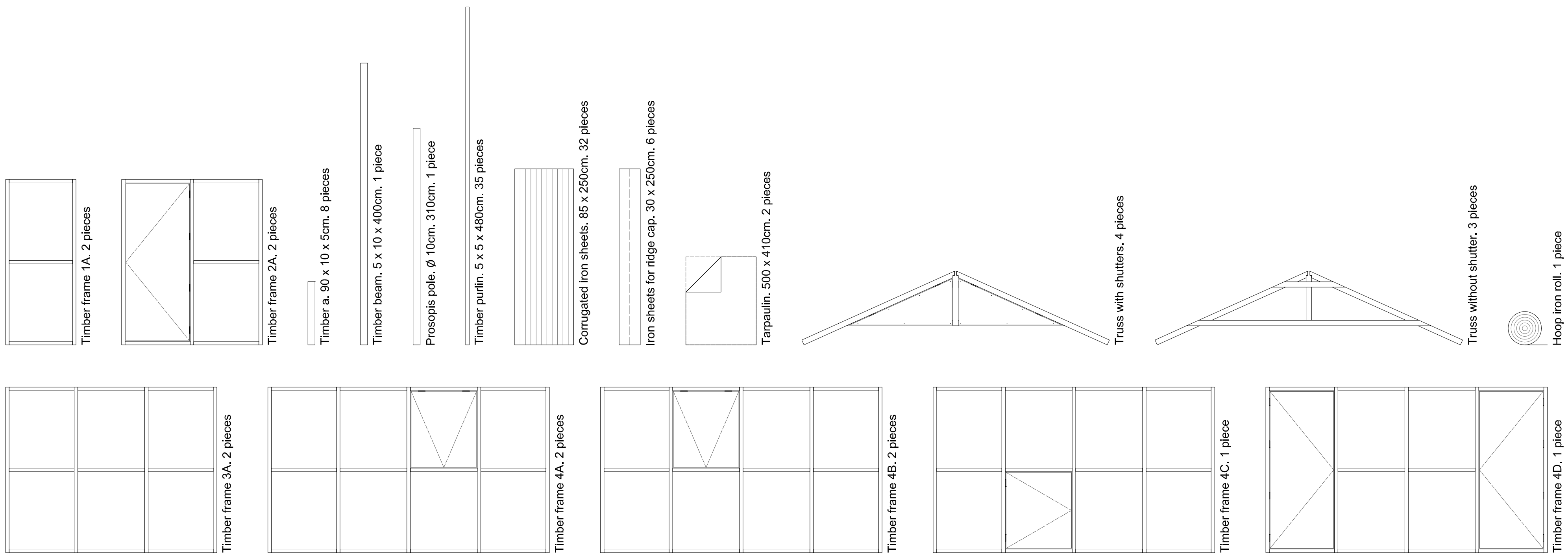


Tool inventory



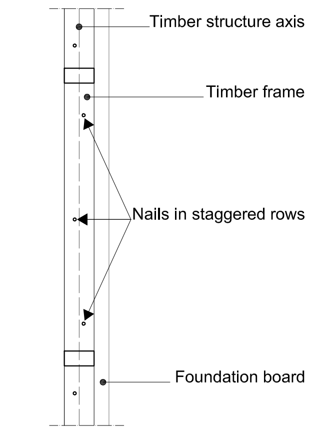


Material inventory for masonry

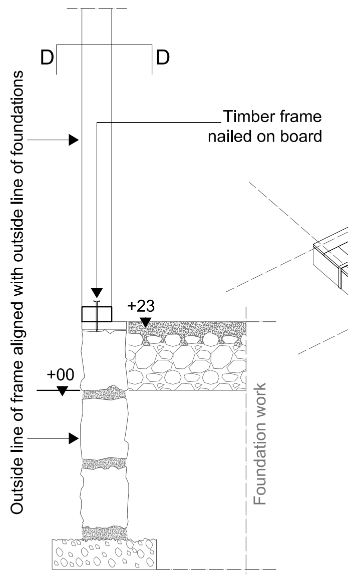


Material inventory for carpentry

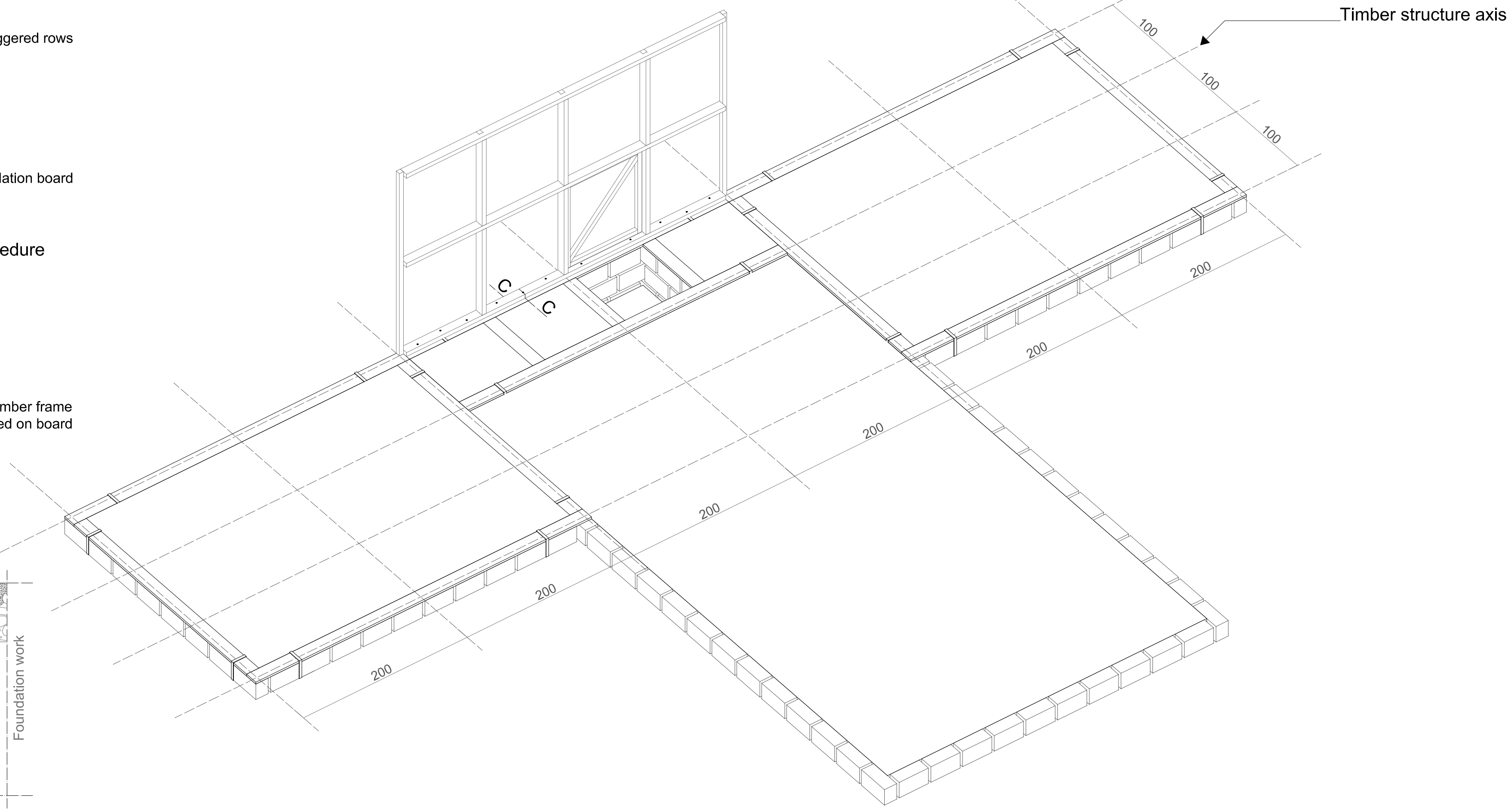
Required tools



Section DD. Nailing procedure



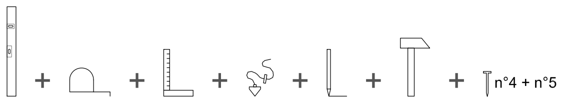
Section CC. Position on foundations



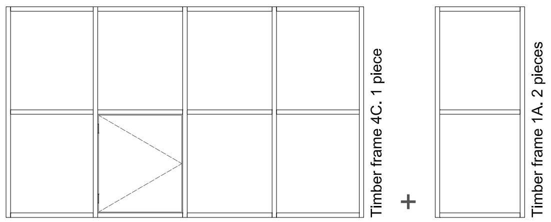
Method for nailing the timber frames

House B3 Manual

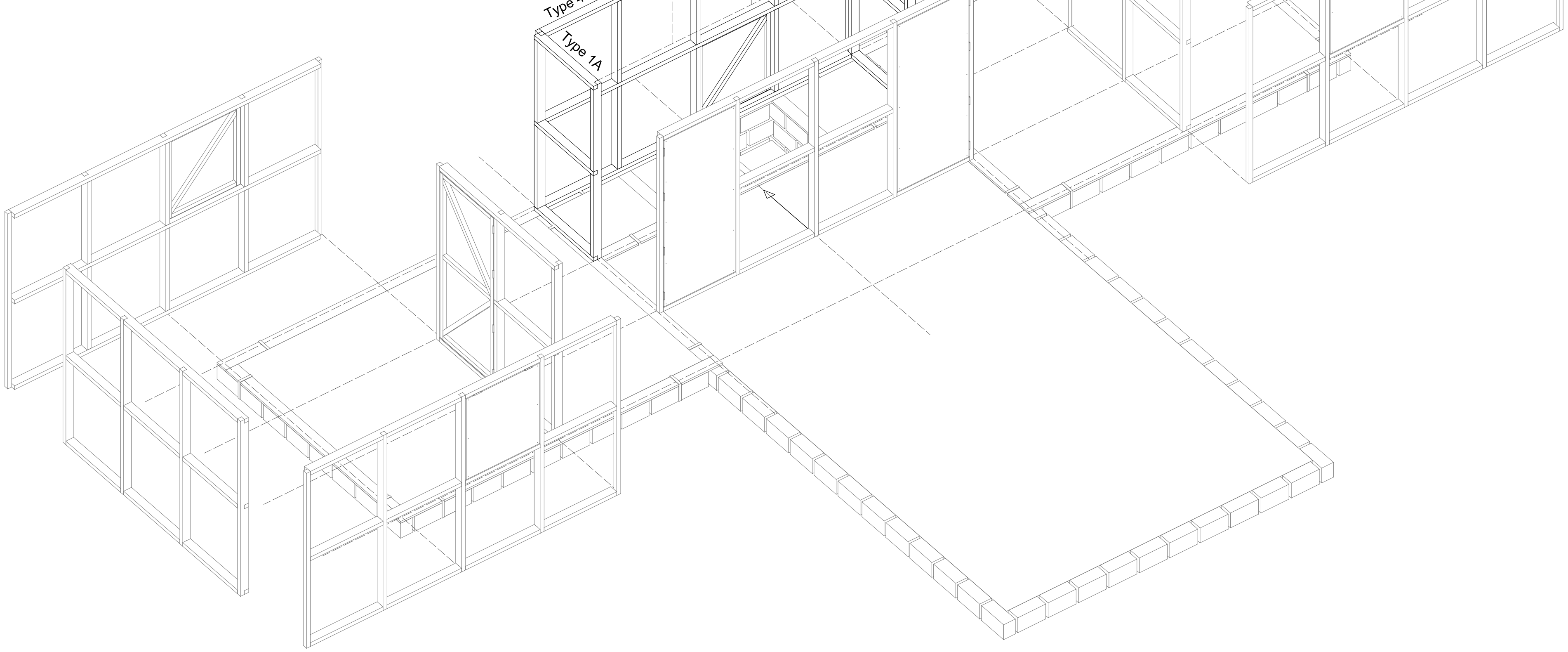
Assembly. 25



Required tools

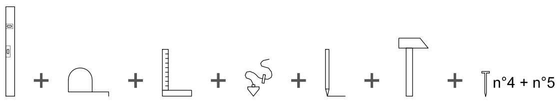


Required material

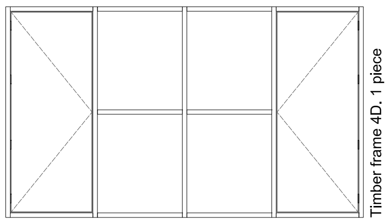


Nailing the timber frames types 4C+1A+1A

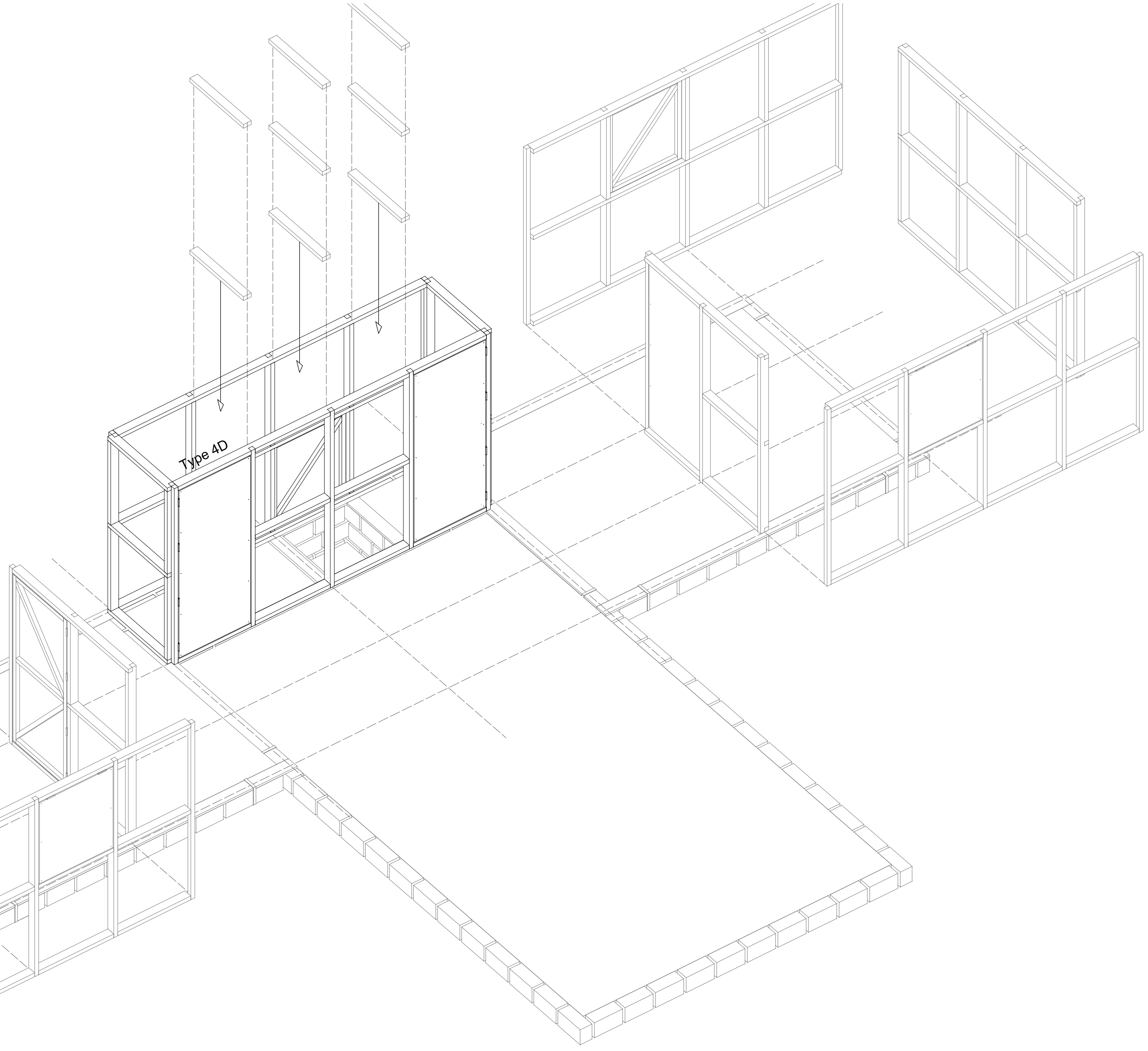
Assembly. 26



Required tools



Required material

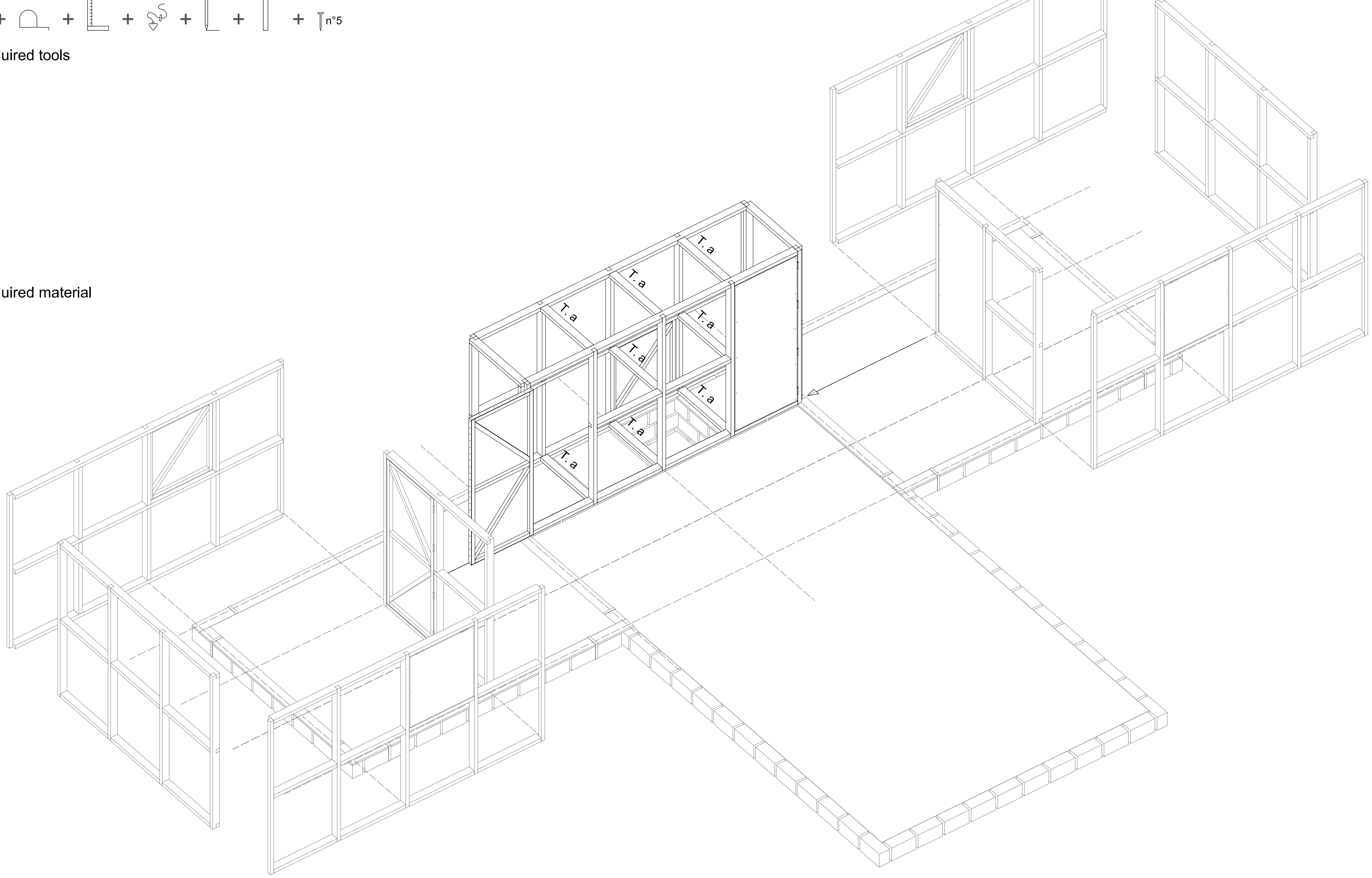


Nailing the timber frame type 4D

Assembly. 27

Required tools

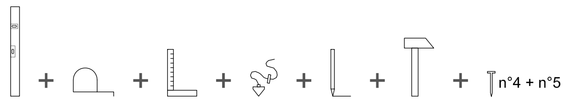
Required material



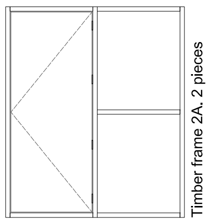
Nailing the timber ‘a’ profiles

House B3 Manual

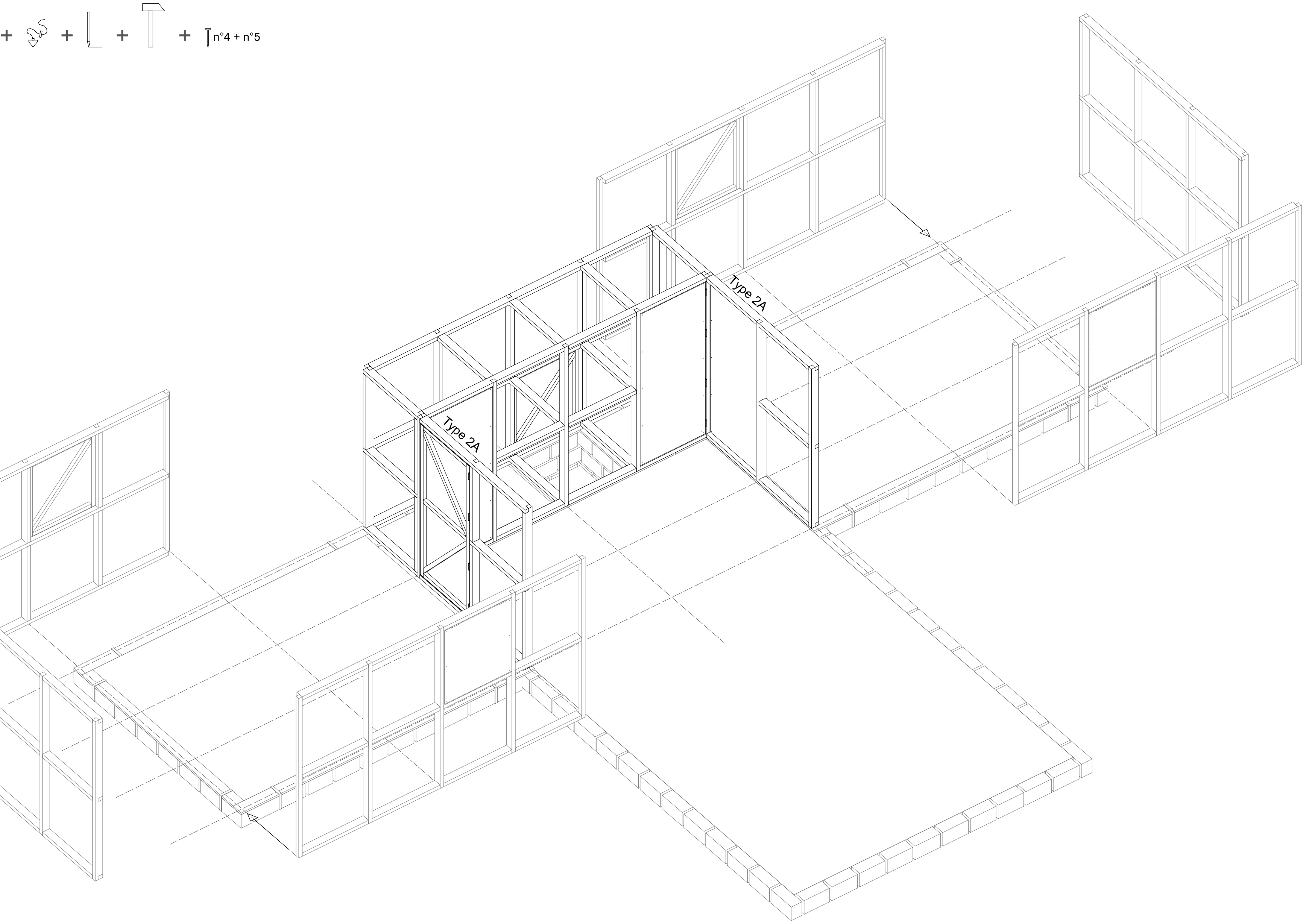
Assembly. 28



Required tools

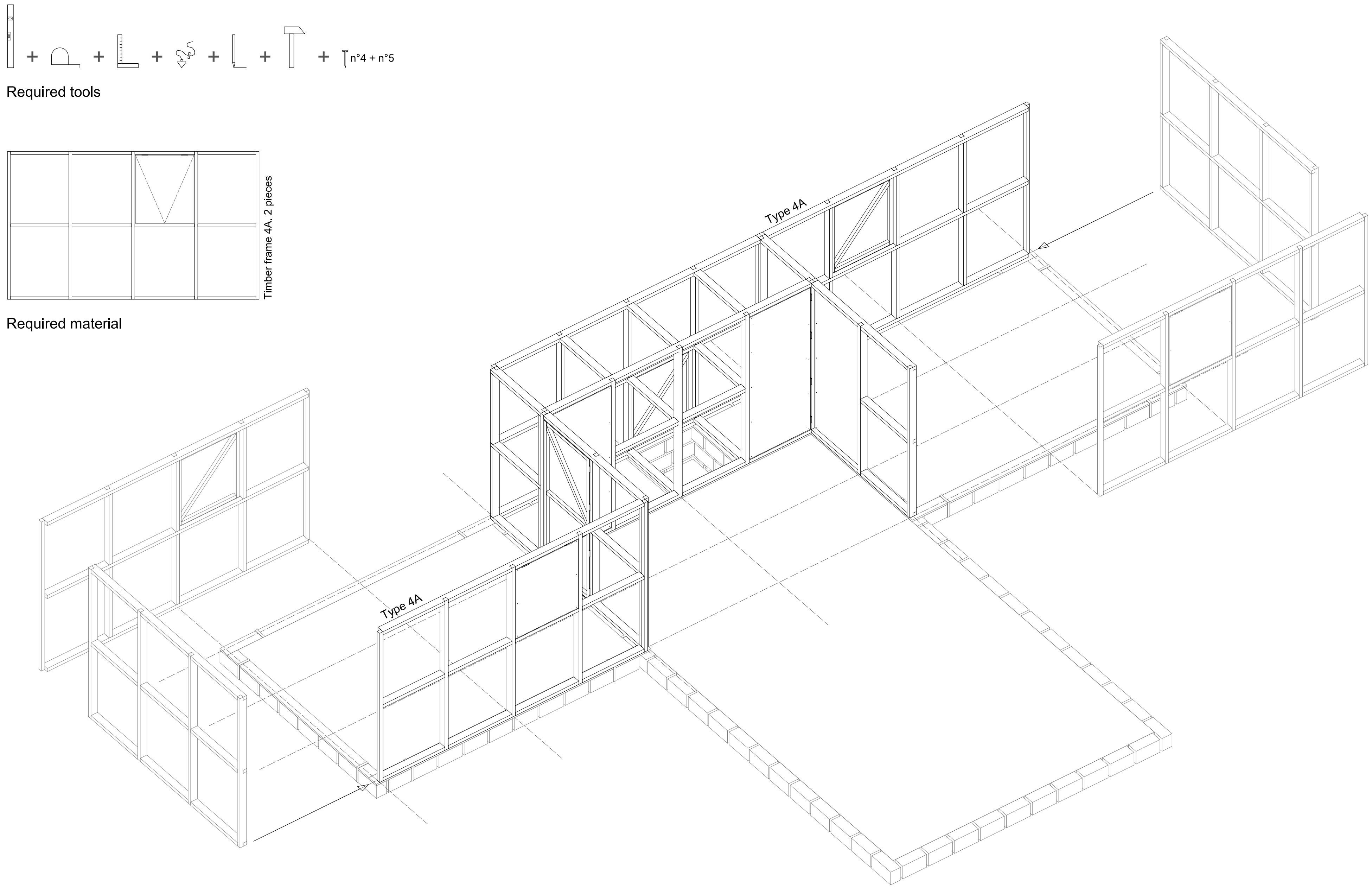


Required material



Nailing the timber frames type 2A

Assembly. 29

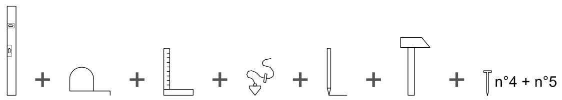


Required tools

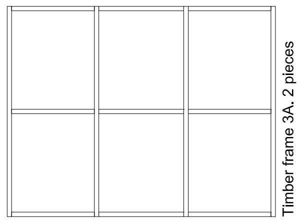
Required material

Nailing the timber frames type 4A

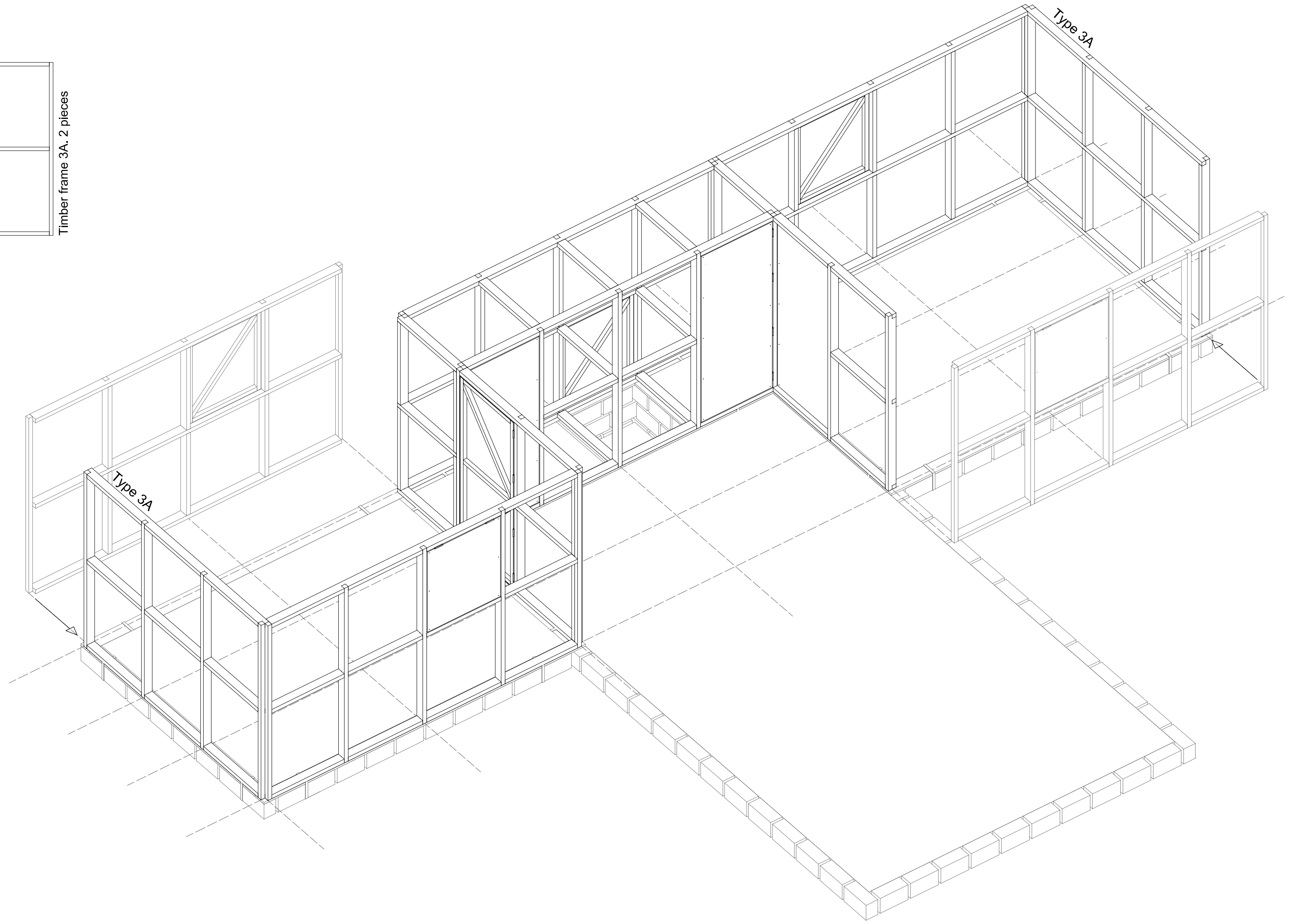
Assembly. 30



Required tools

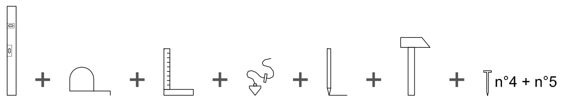


Required material

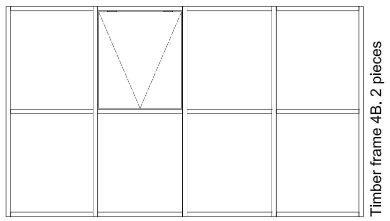


Nailing the timber frames type 3A

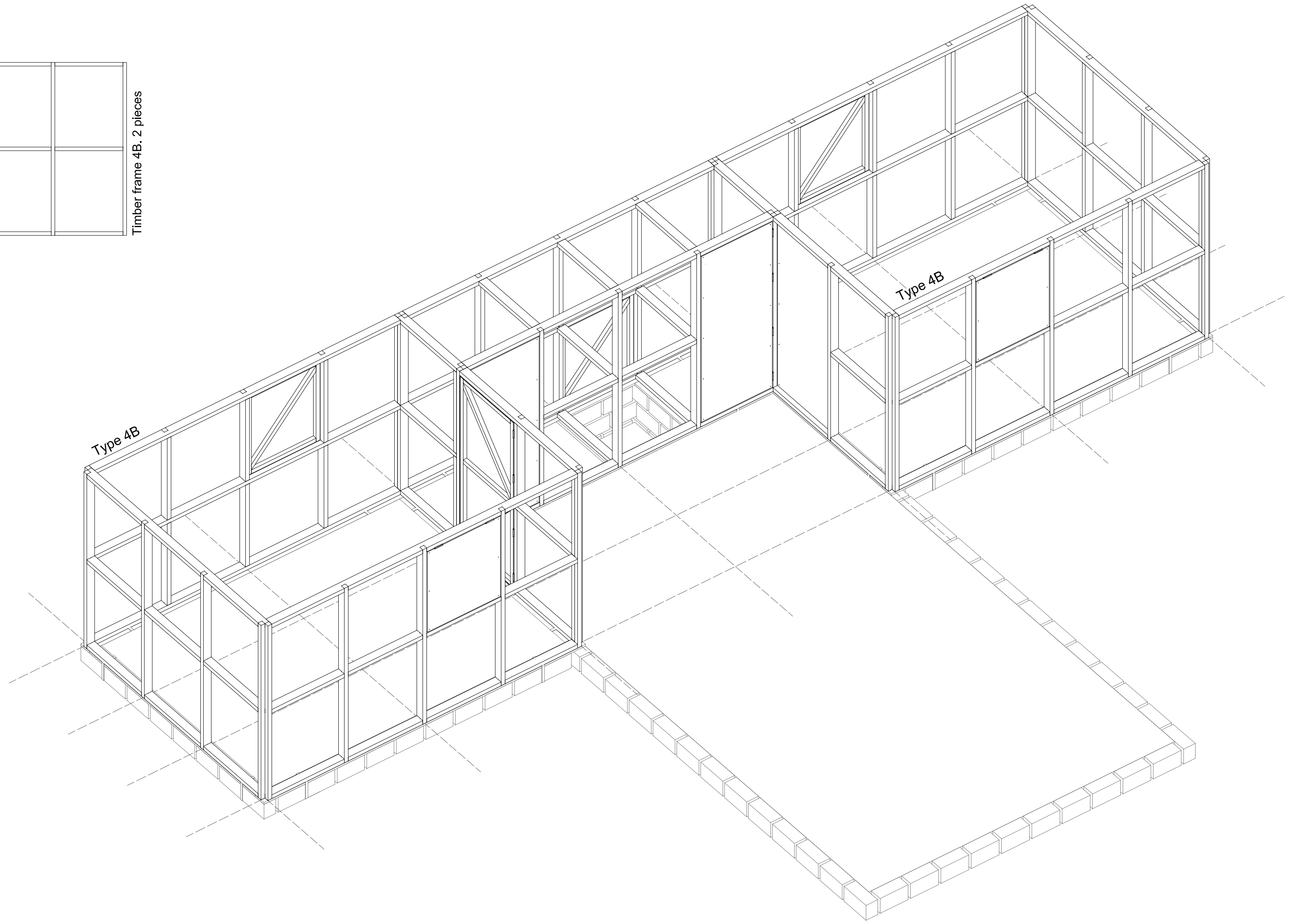
Assembly. 31



Required tools



Required material

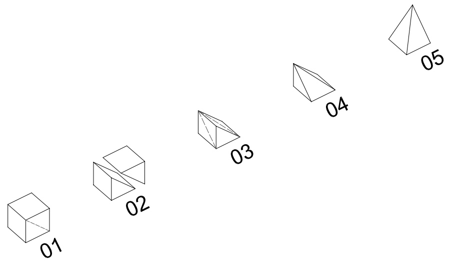


Nailing the timber frames type 4B

House B3 Manual

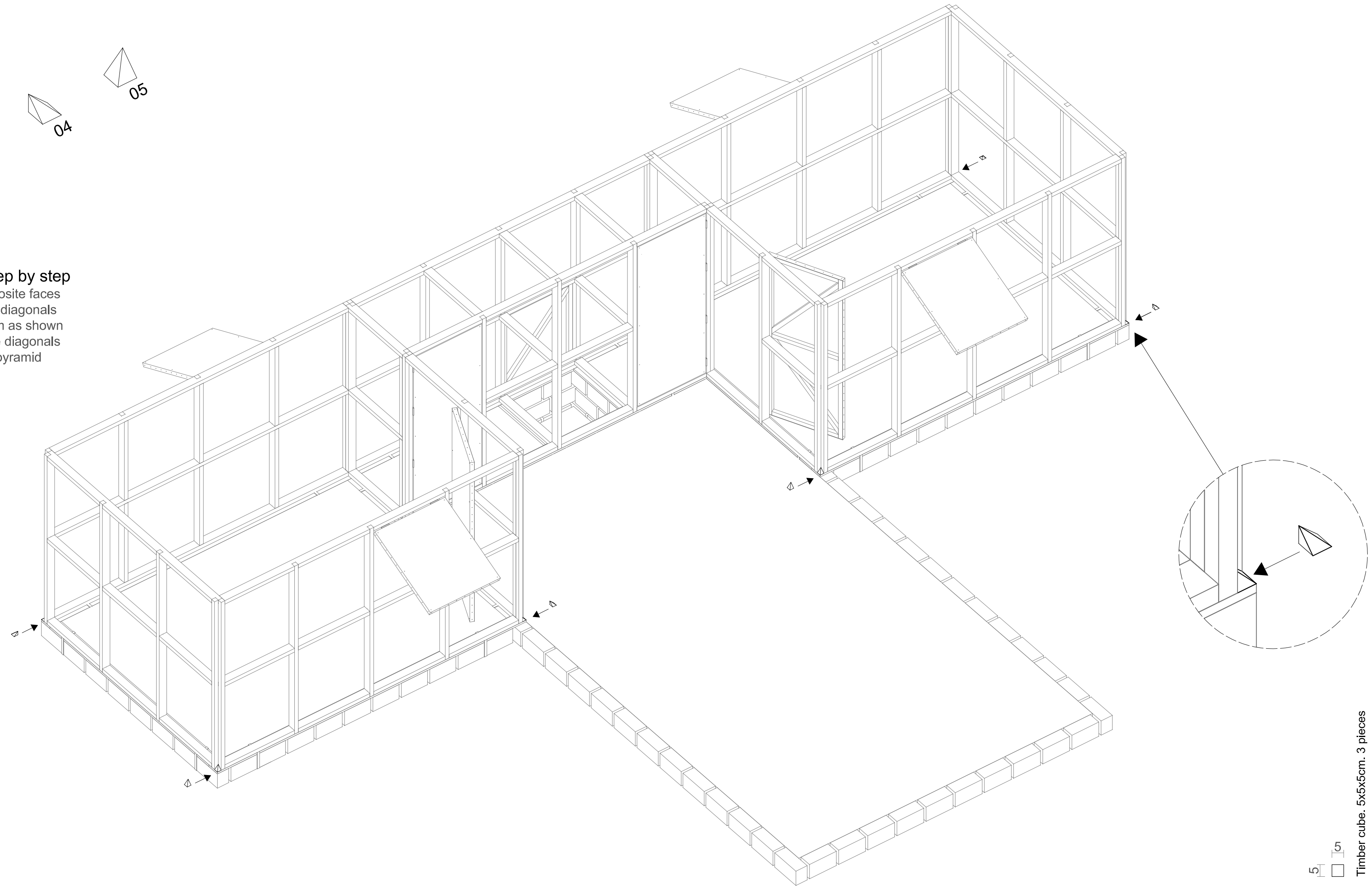
Assembly. 32

Required tools



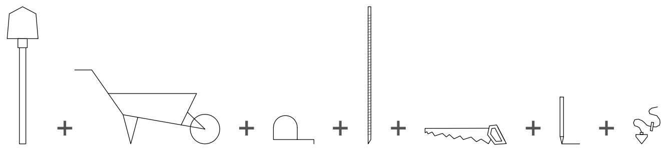
Wood corner fabrication step by step

01. Tracing of diagonals on 2 opposite faces
02. Cutting the cube following the diagonals
03. Tracing diagonals on the prism as shown
04. Cutting the prism following the diagonals
05. Front view of the figure = 1/4 pyramid



Required material

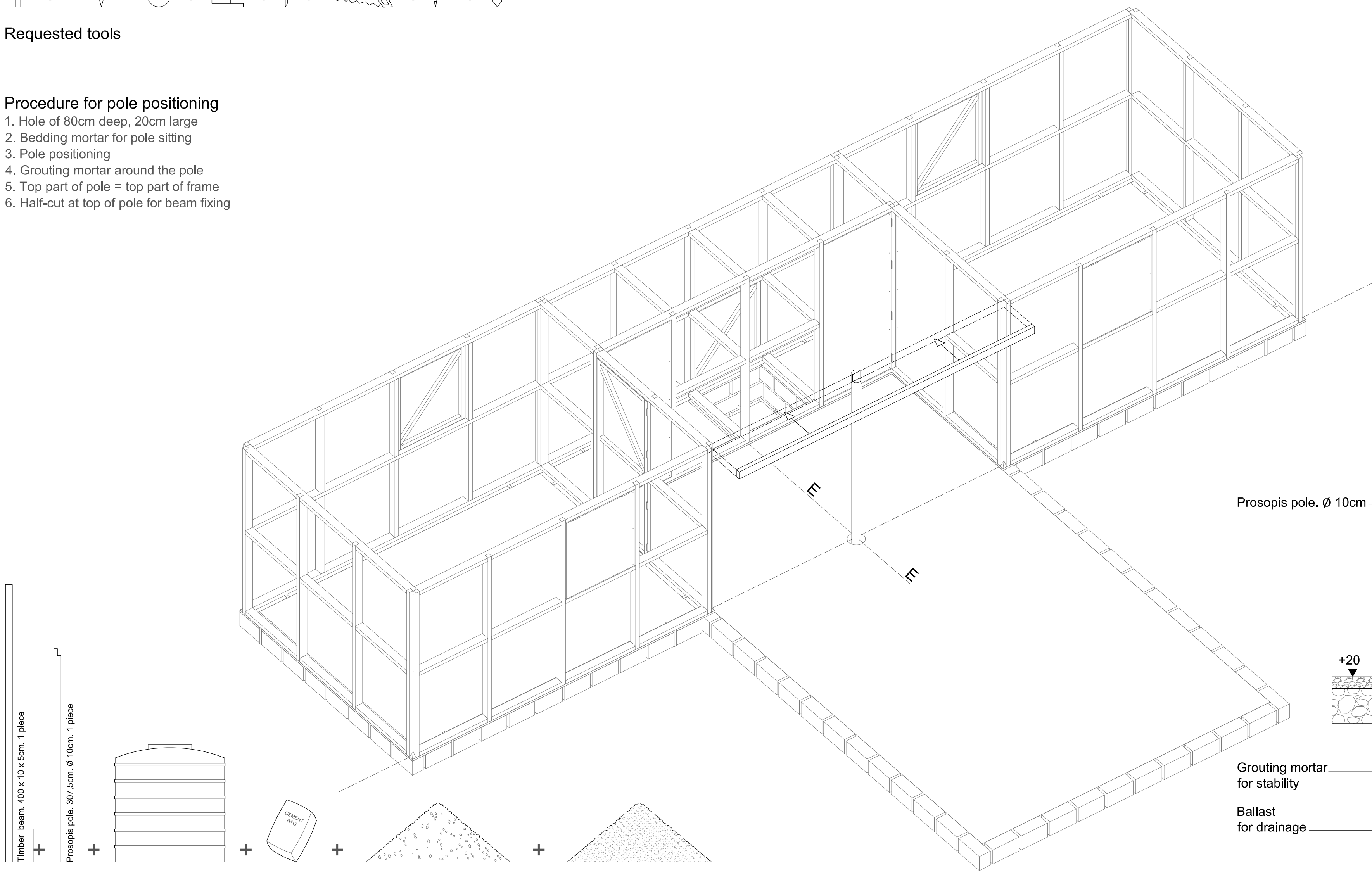
Fabrication and nailing of wood corners



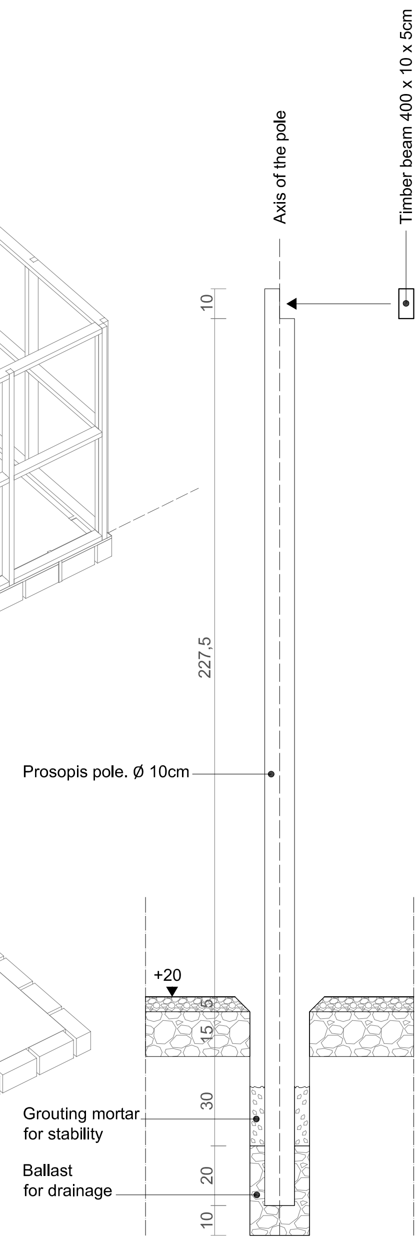
Requested tools

Procedure for pole positioning

1. Hole of 80cm deep, 20cm large
2. Bedding mortar for pole sitting
3. Pole positioning
4. Grouting mortar around the pole
5. Top part of pole = top part of frame
6. Half-cut at top of pole for beam fixing



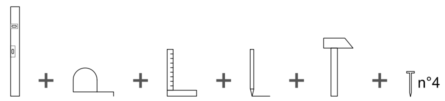
Requested material



Section EE. Pole/beam detail

Prosopis pole foundations

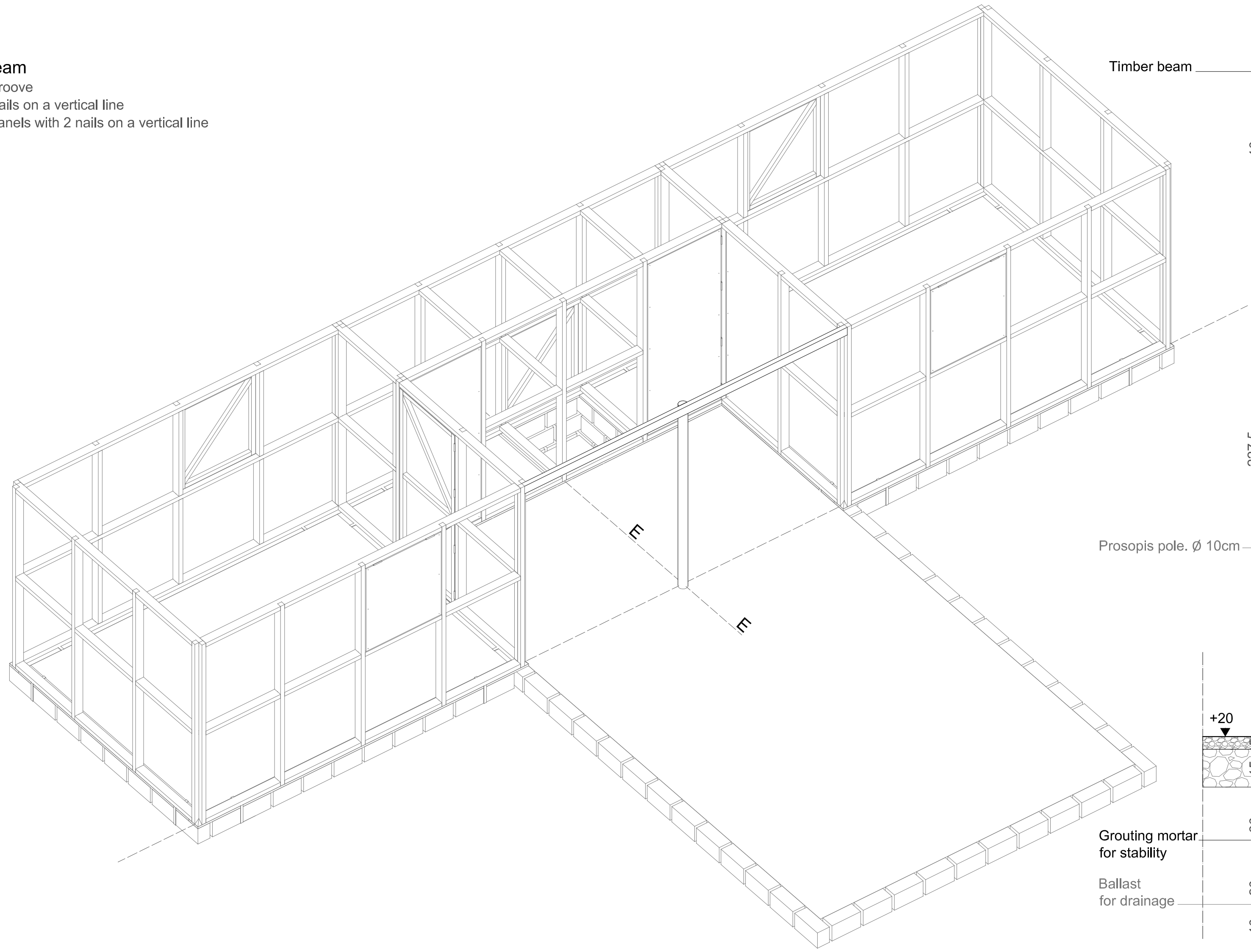
Assembly. 34

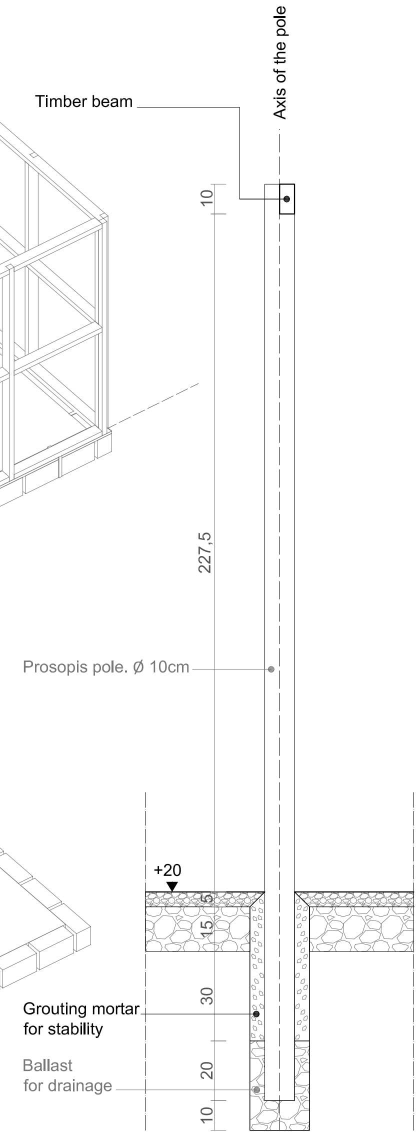


Required tools

Procedure for positioning the beam

1. Positioning timber beam into pole's groove
2. Nailing the beam to the pole with 2 nails on a vertical line
3. Nailing the beam to the 4A and 4B panels with 2 nails on a vertical line



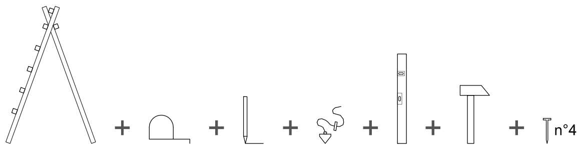


Section EE. Pole/beam detail

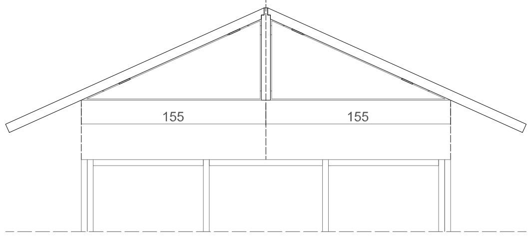
Nailing the timber beam

House B3 Manual

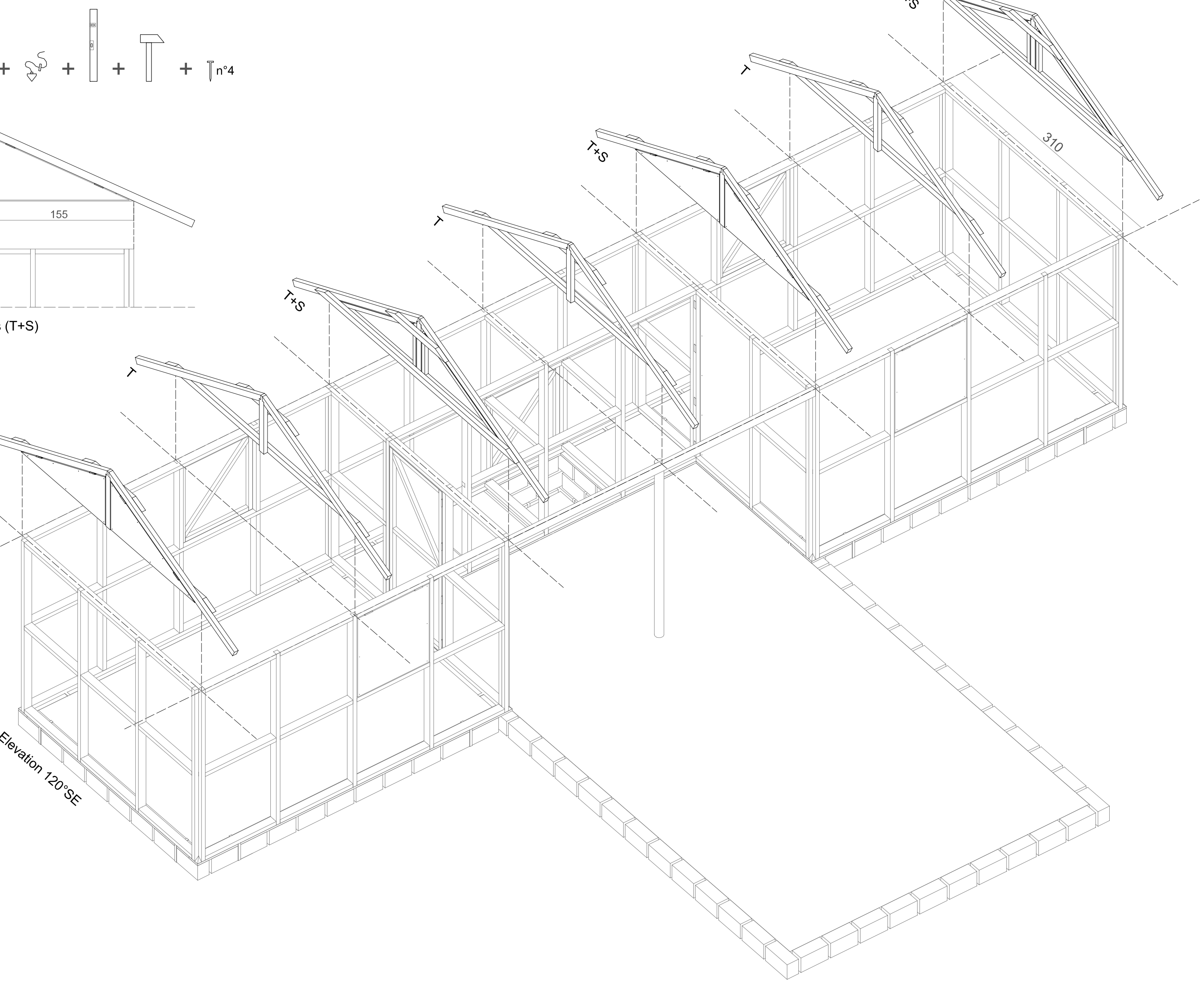
Assembly. 35



Requested tools



Elevation 120°SE. Truss with Shutters (T+S)



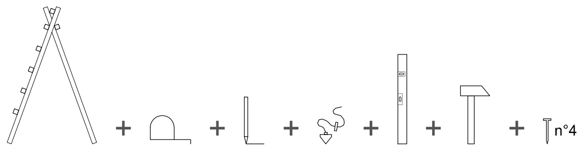
Legend - axonometric view

T = Trusses without shutter. 3 pieces

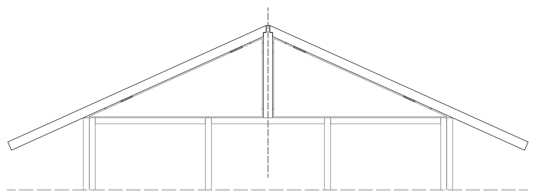
T+S = Trusses with Shutters. 4 pieces

Positioning the trusses

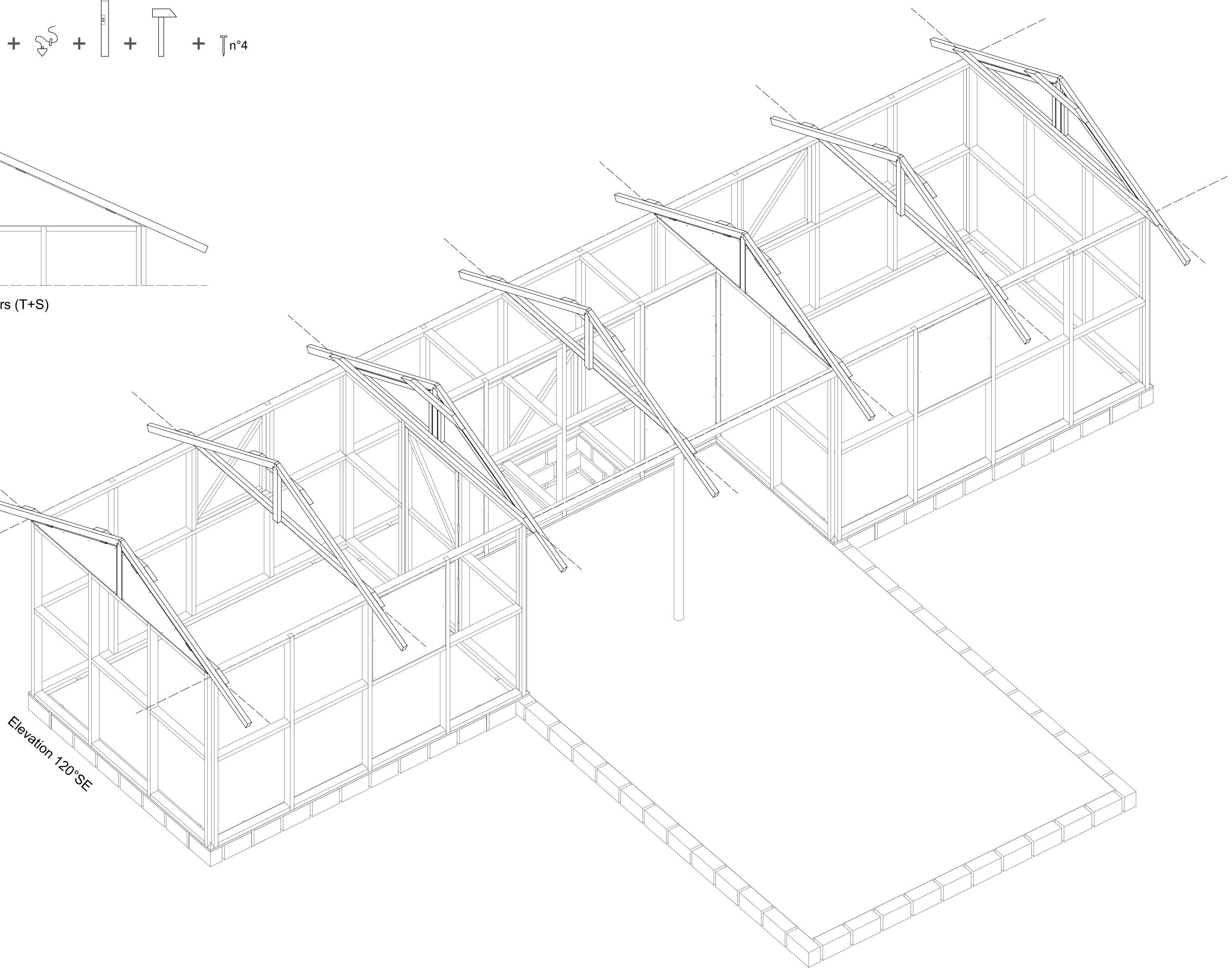
Assembly. 36



Requested tools

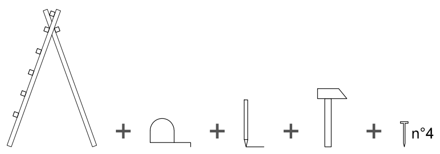


Elevation 120°SE. Truss with Shutters (T+S)

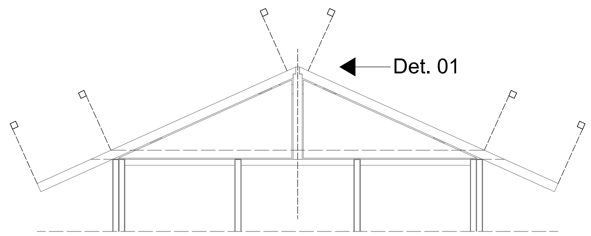


Nailing the trusses

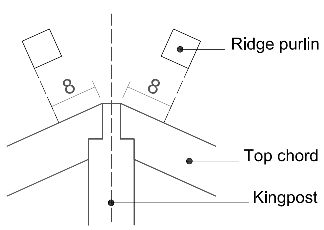
Assembly. 37



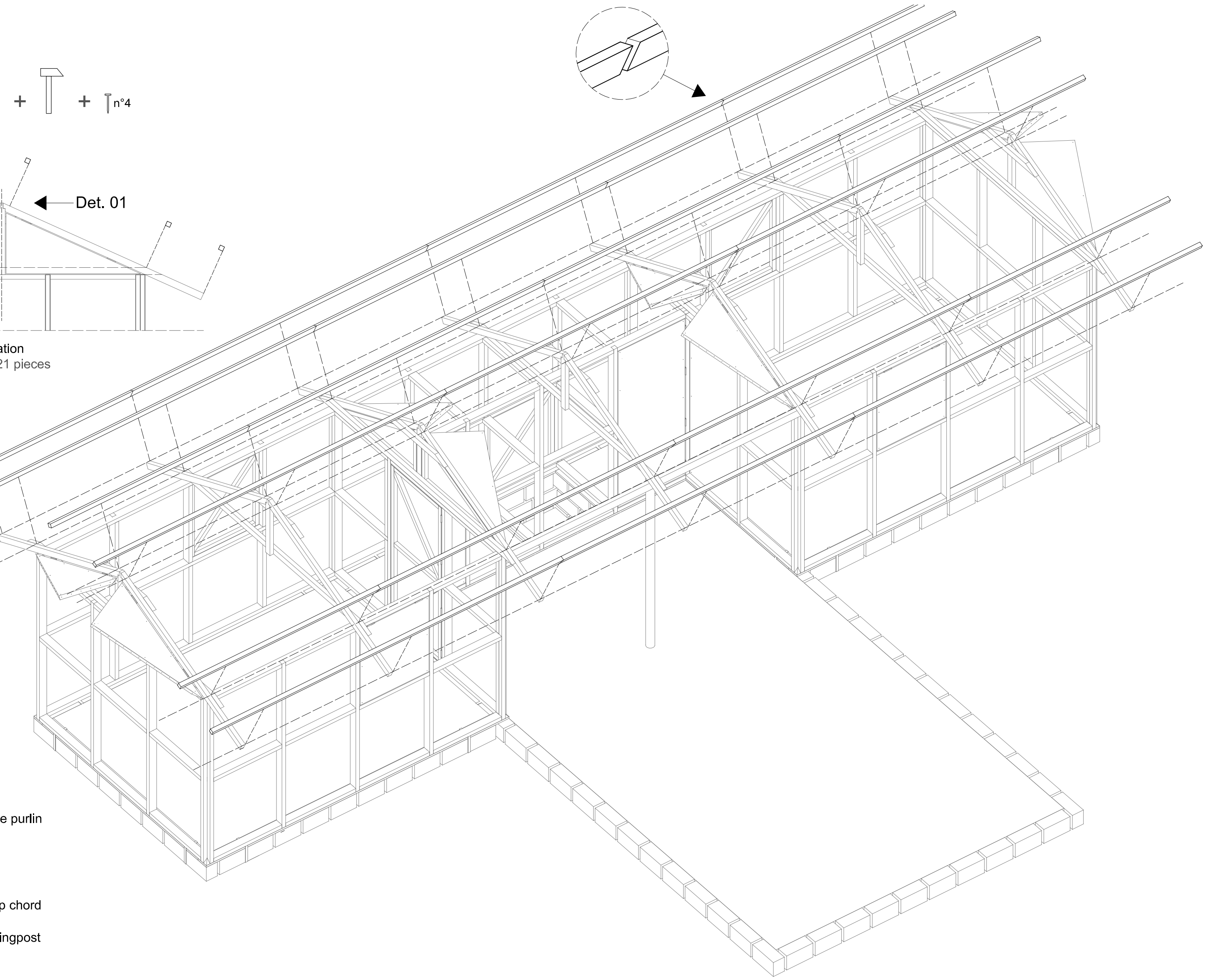
Requested tools



Elevation 120°SE. Main purlins location
Purlins with timber 5 x 5 x 480cm. 21 pieces



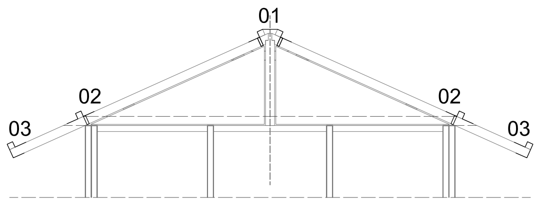
Det. 01
Purlins positioning for ridge cap nailing



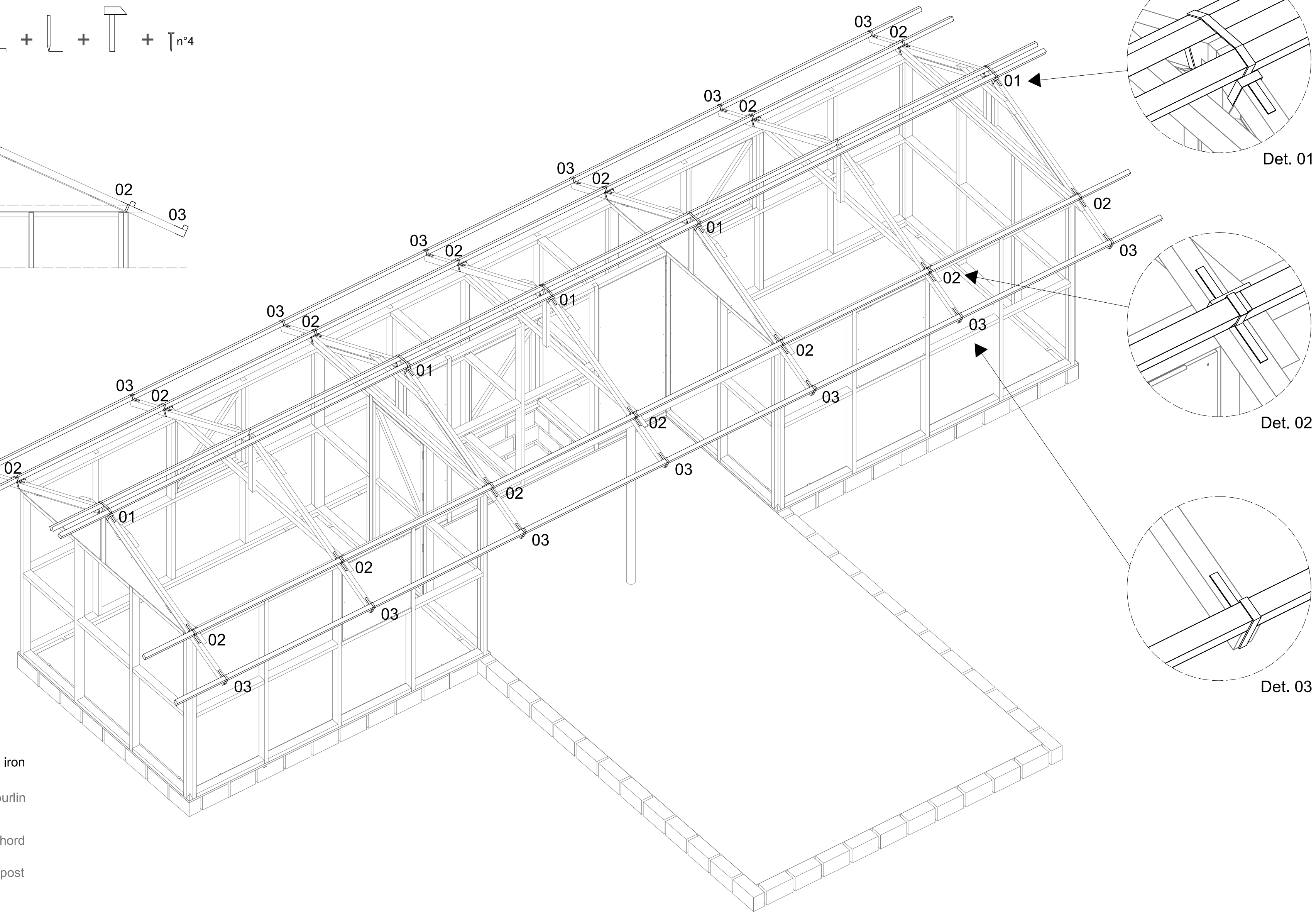
Positioning the main purlins

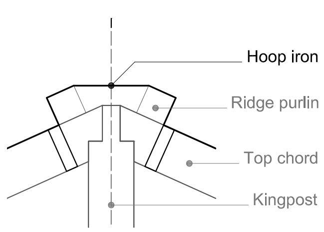
House B3 Manual
Assembly. 38

Requested tools and material



Elevation 120°SE. Hoop irons location



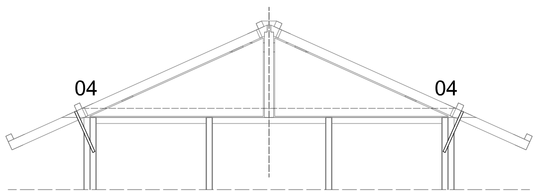


Det. 01
Nailing the ridge purlins with a hoop iron

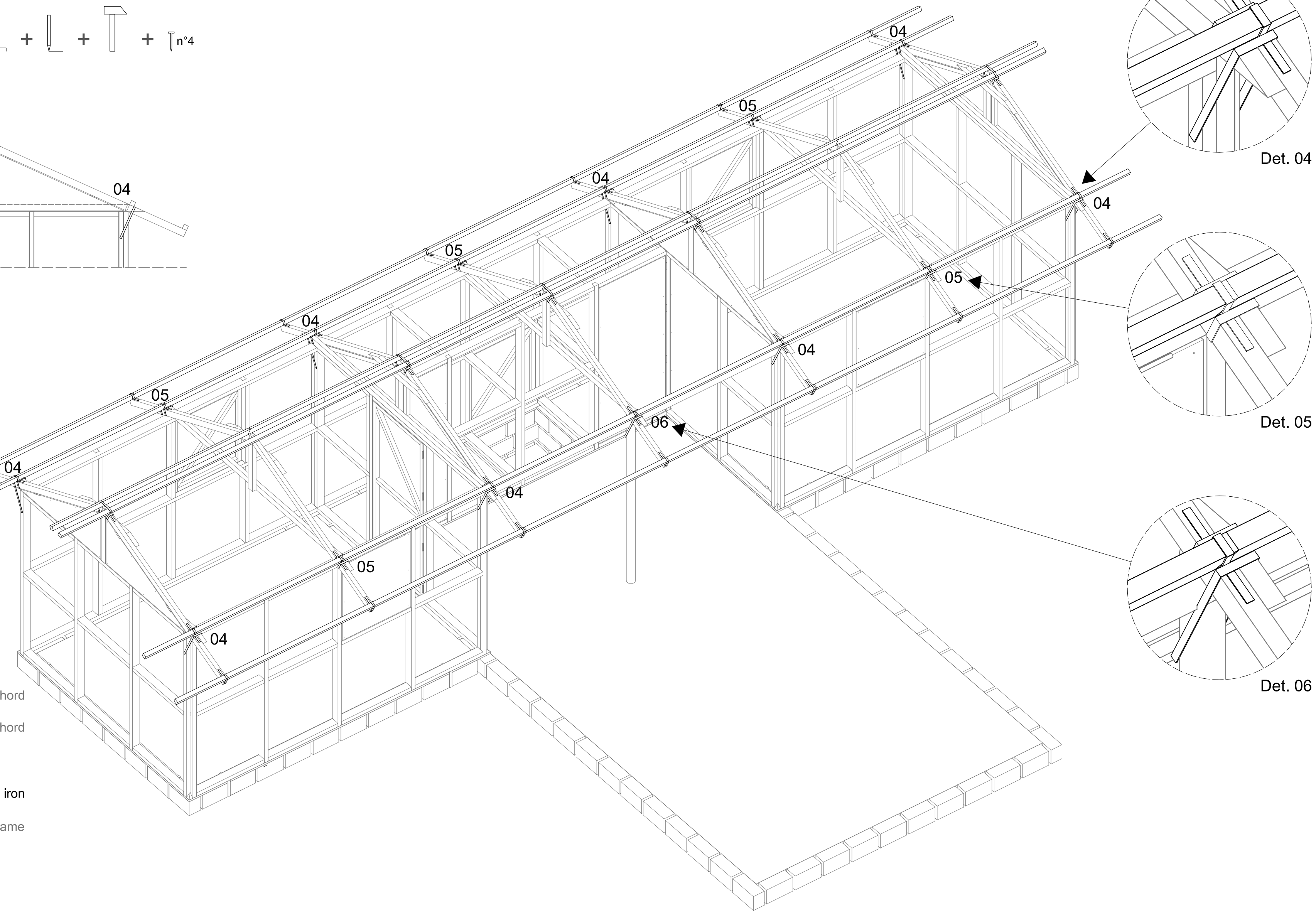
Nailing the purlins to top chords with hoop irons

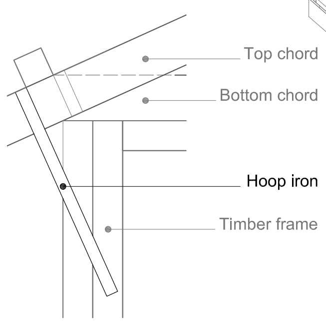
Assembly. 39

Requested tools and material



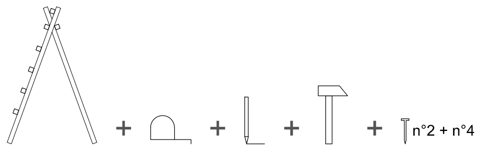
Elevation 120°SE. Hoop irons location



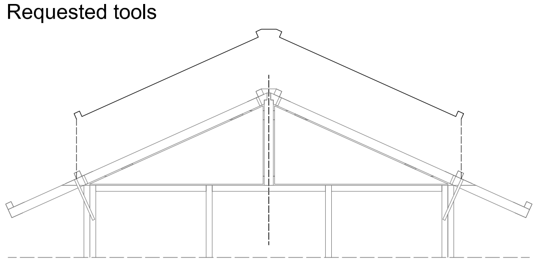


Det. 04
Nailing the top chord with a hoop iron

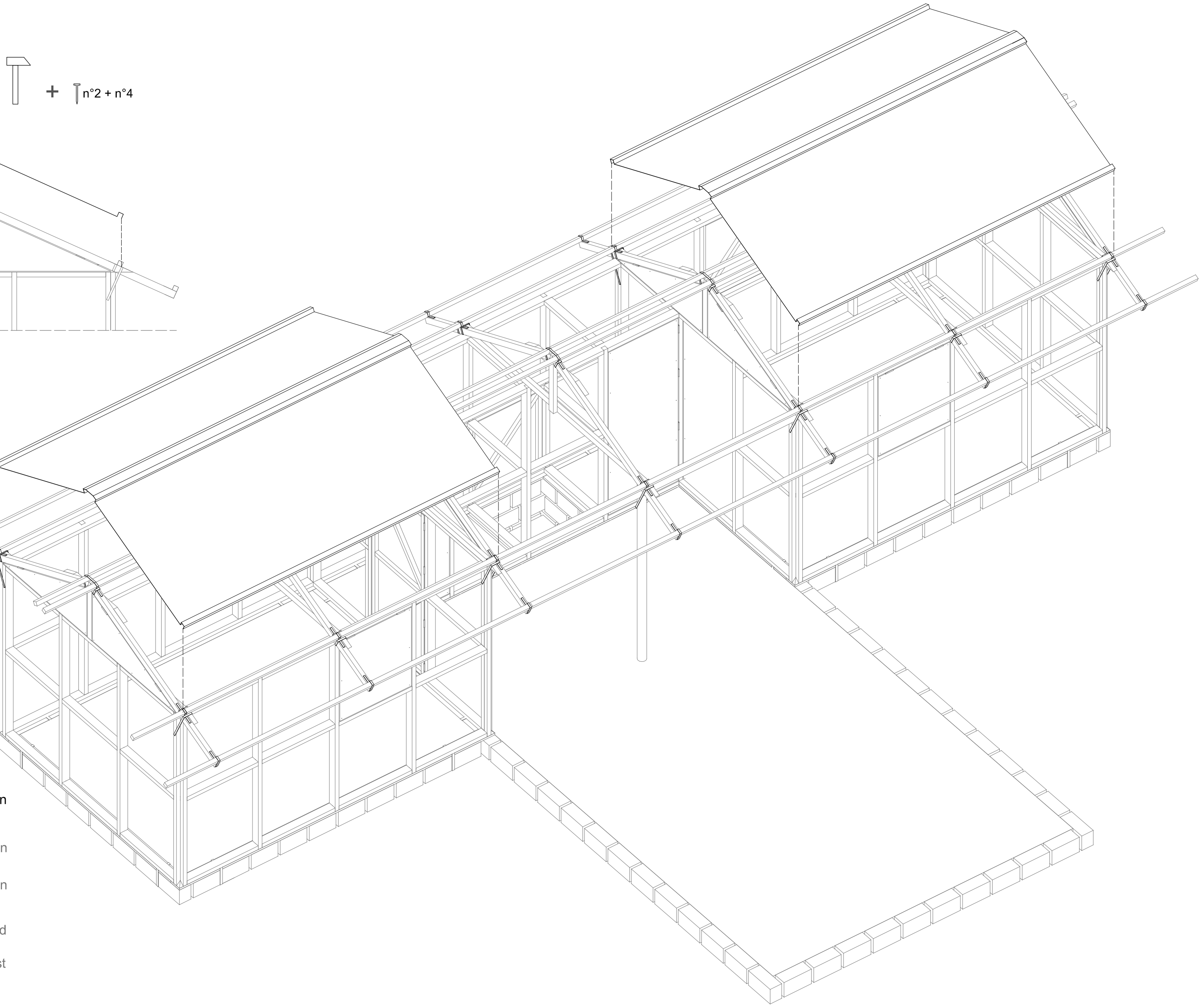
Nailing the top chords to timber frame structure with hoop irons

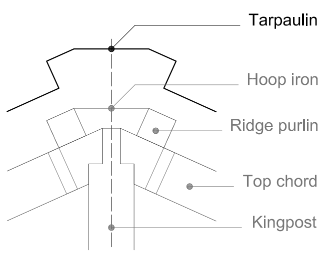


Requested tools



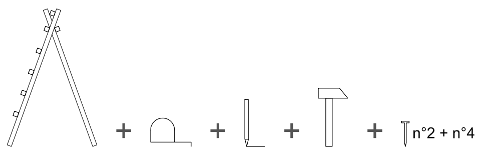
Elevation 120°SE. Tarpaulin location
Tarpaulin 500 x 410cm. 2 pieces



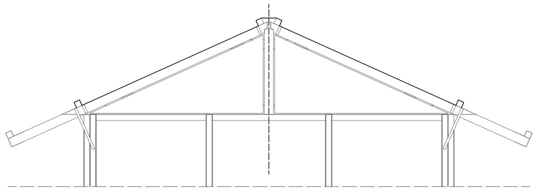


Det. 01
Nailing the tarpaulin to the ridge purlins

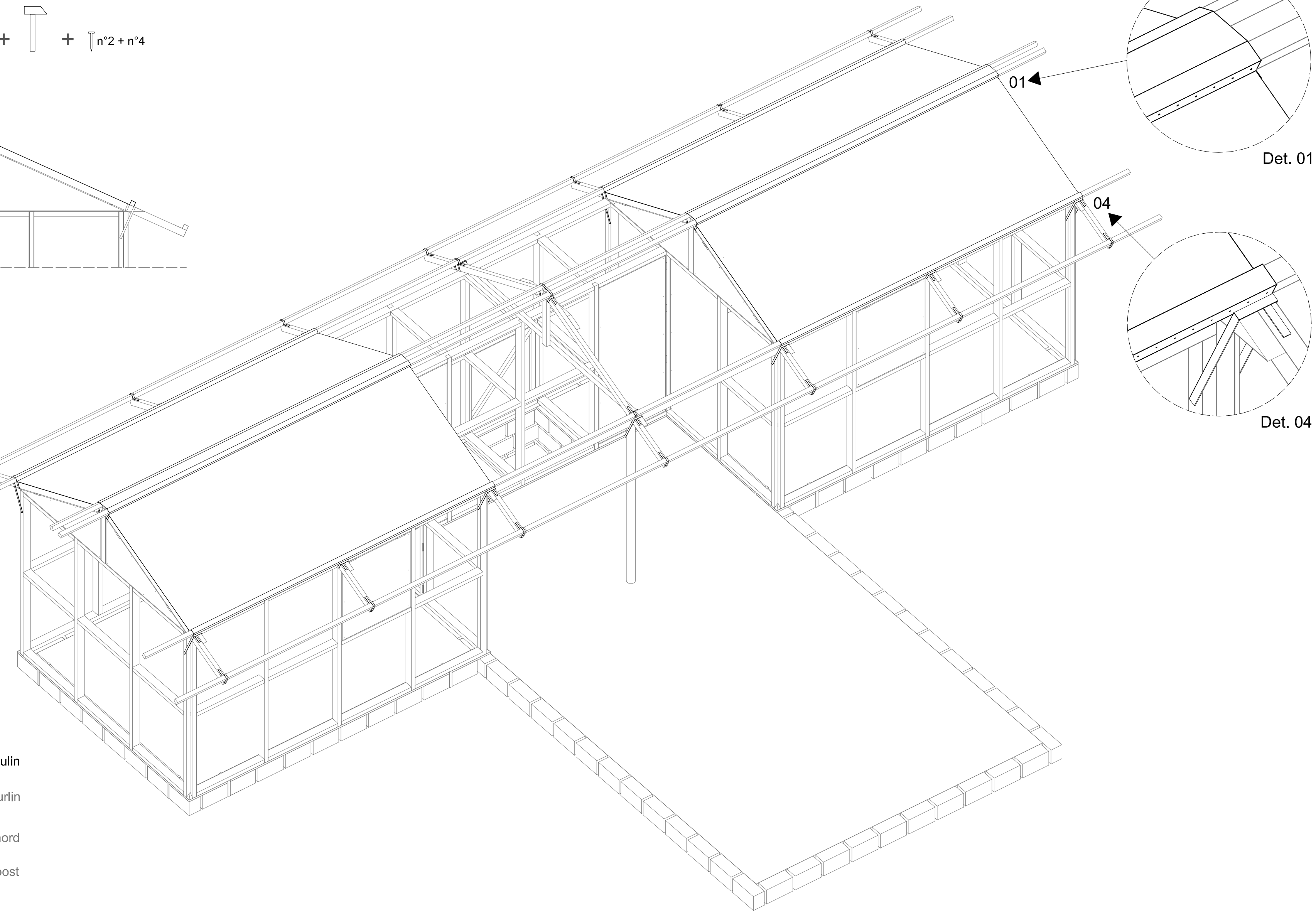
Positioning the tarpaulin

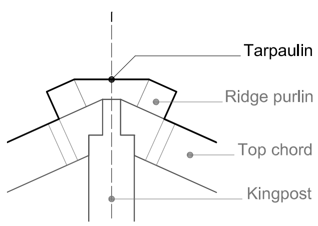


Requested tools



Elevation 120°SE. Tarpaulin location

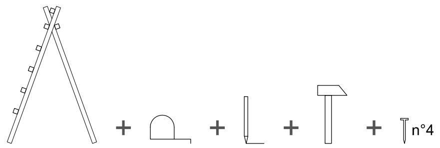




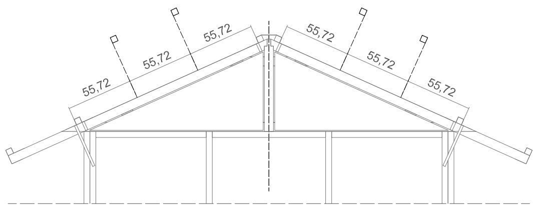
Det. 01
Nailing the tarpaulin to the ridge purlins

Assembly. 42

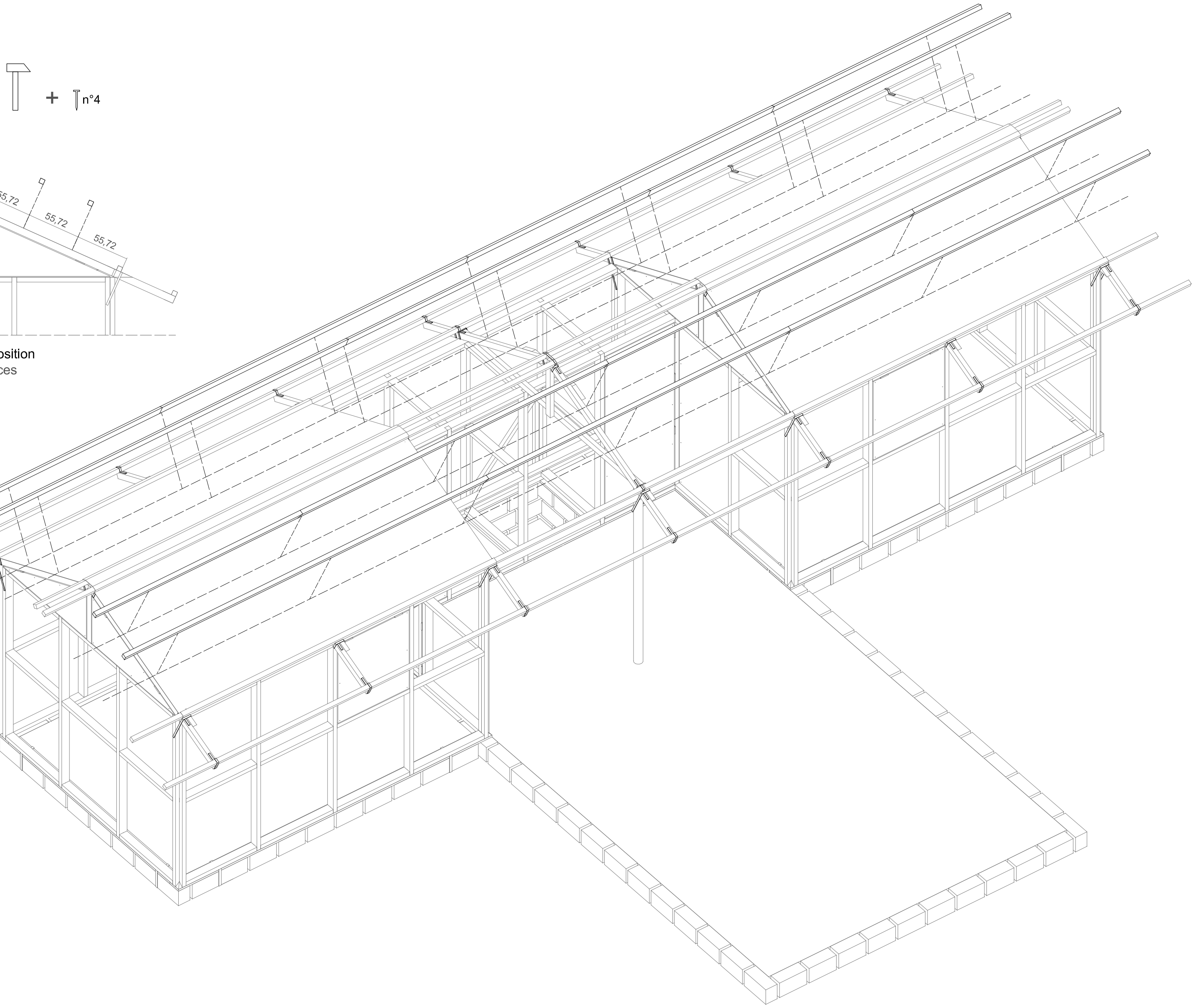
Nailing the tarpaulin to main purlins



Requested tools



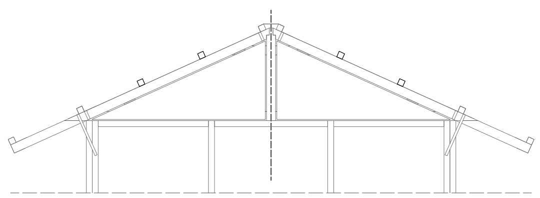
Elevation 120°SE. Intermediate purlins position
Purlins with timber 5 x 5 x 480cm. 14 pieces



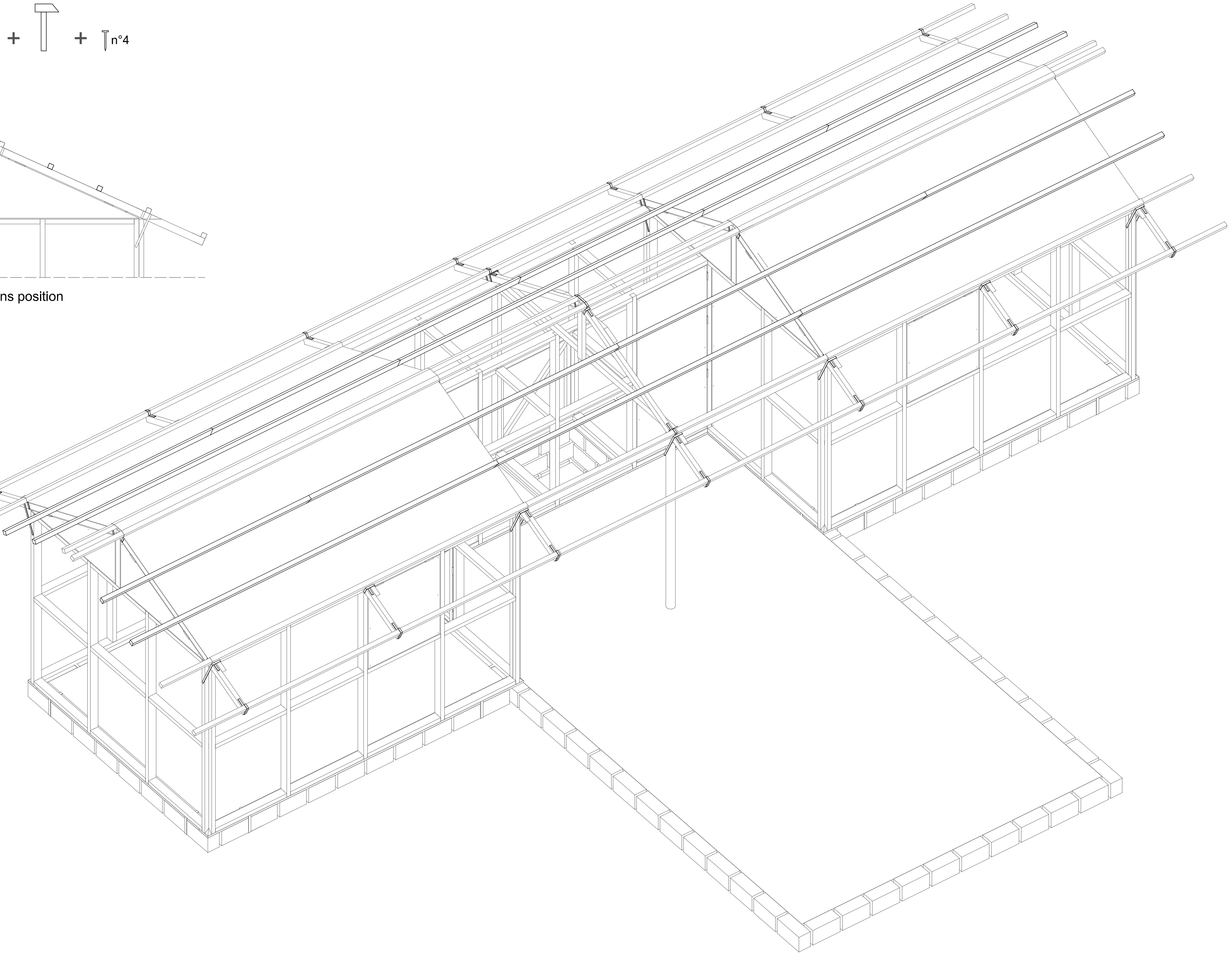
Positioning the intermediate purlins

Assembly. 43

Requested tools

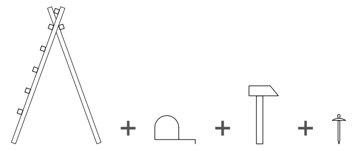


Elevation 120°SE. Intermediate purlins position

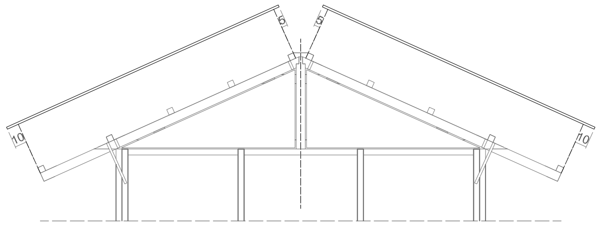


Nailing the intermediate purlins

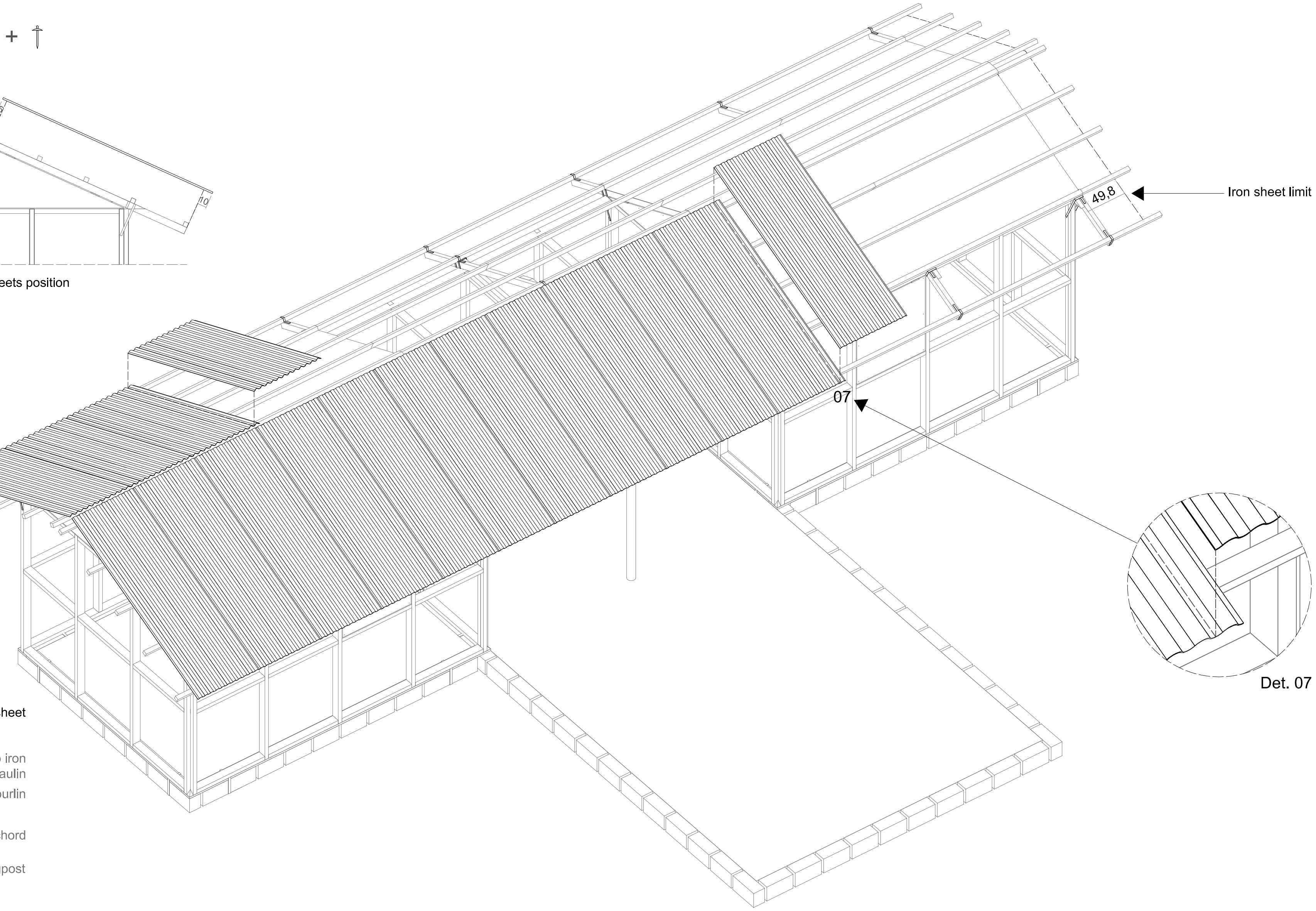
Assembly. 44

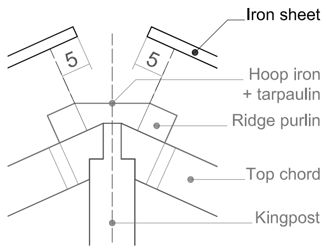


Necessary tools



Elevation 120°SE. Corrugated iron sheets position
Iron sheets 85 x 250cm. 32 pieces



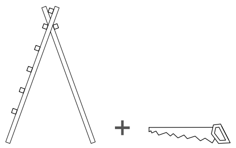


Det. 01
Placing the iron sheets on the roof structure

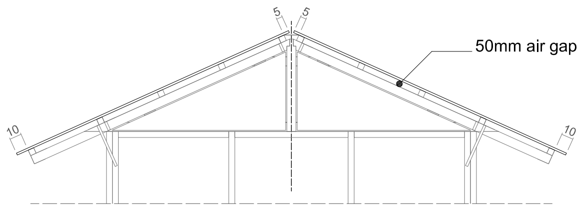
House B3 Manual

Assembly. 45

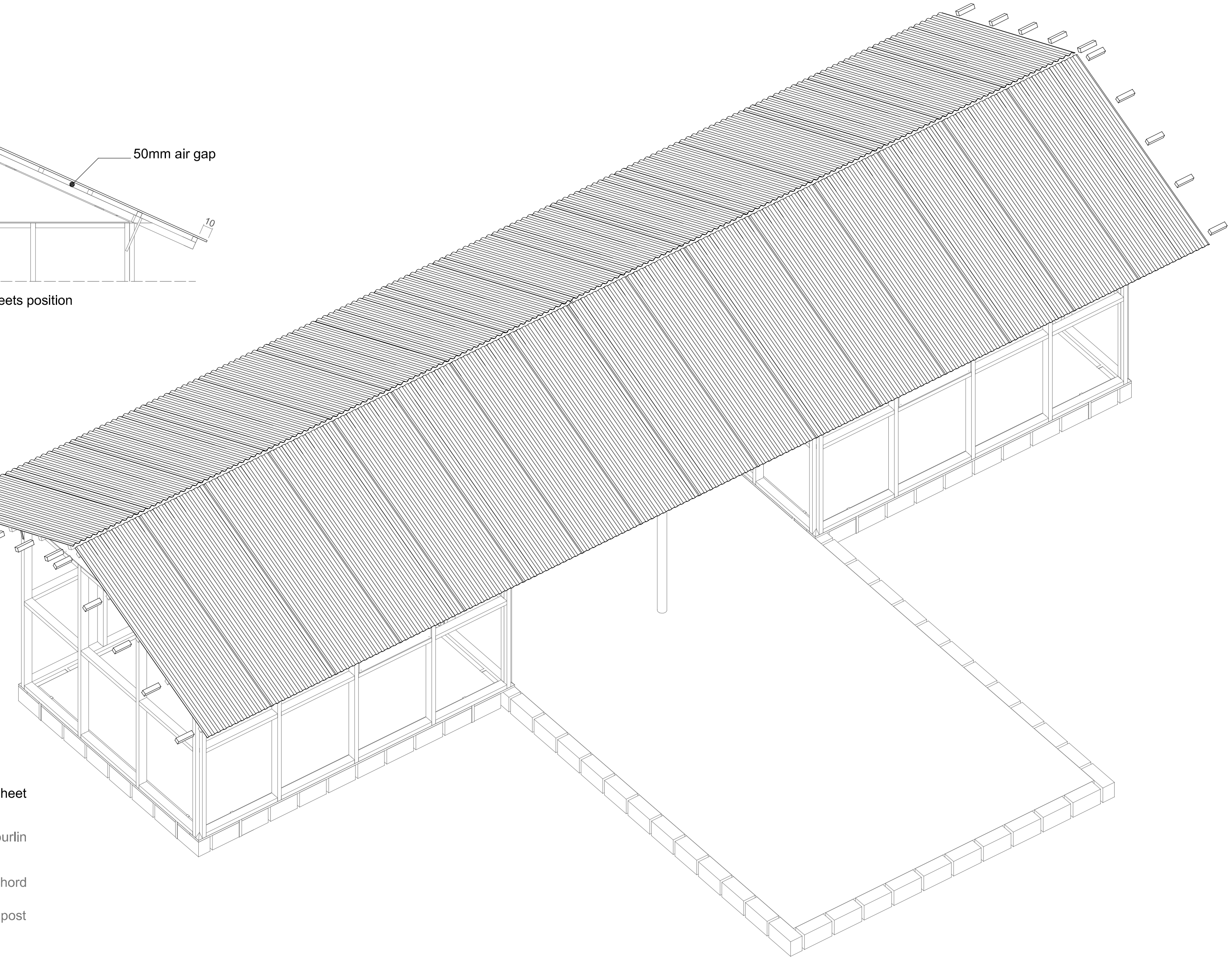
Nailing the corrugated iron sheets

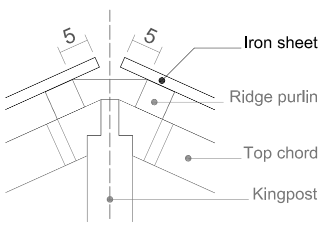


Requested tools



Elevation 120°SE. Corrugated iron sheets position



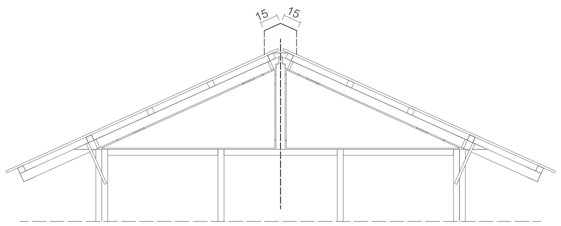


Det. 01
Nailing the iron sheets on the ridge purlins

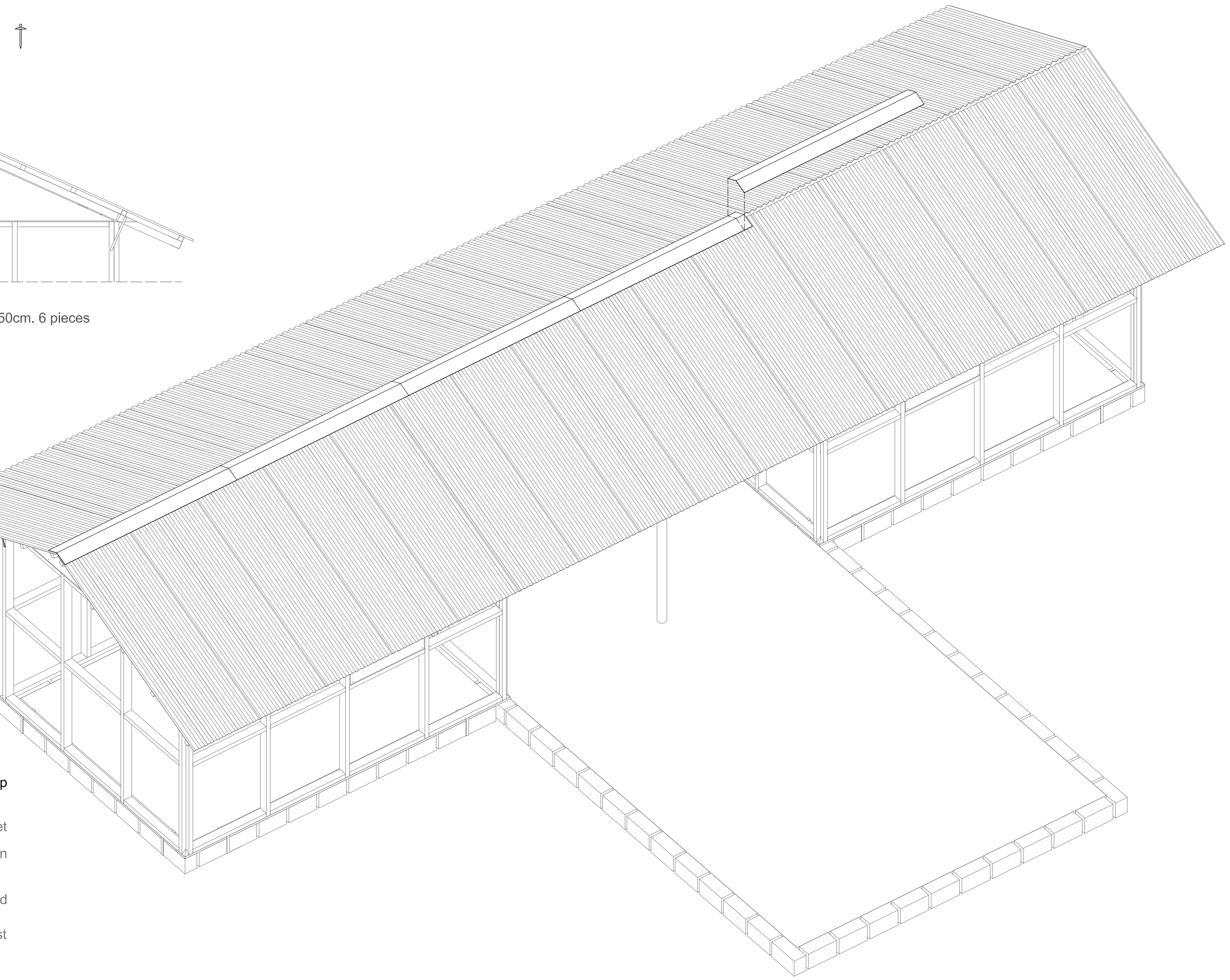
Cutting the purlin edges

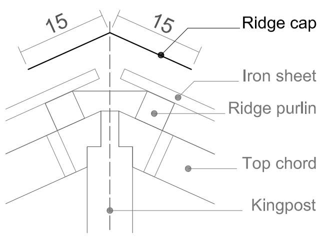
Assembly. 46

Requested tools



Elevation 120°SE. Ridge caps position
Necessary material = Ridge caps 30 x 250cm. 6 pieces

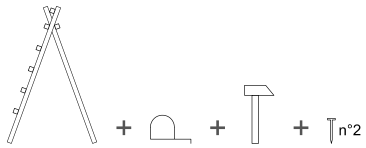




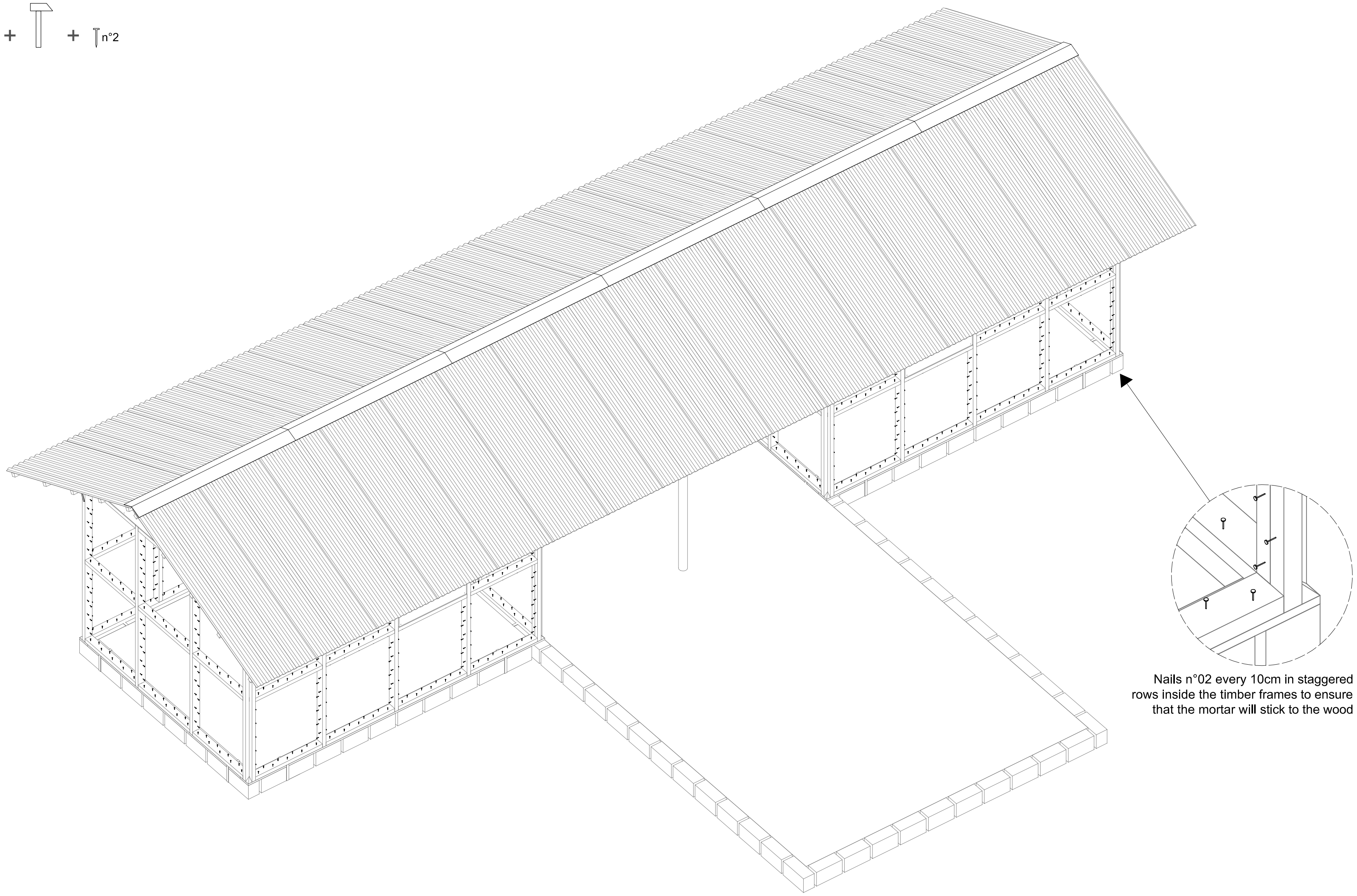
Det. 01
Nailing the ridge caps on the ridge purlins

Nailing the ridge caps

Assembly. 47

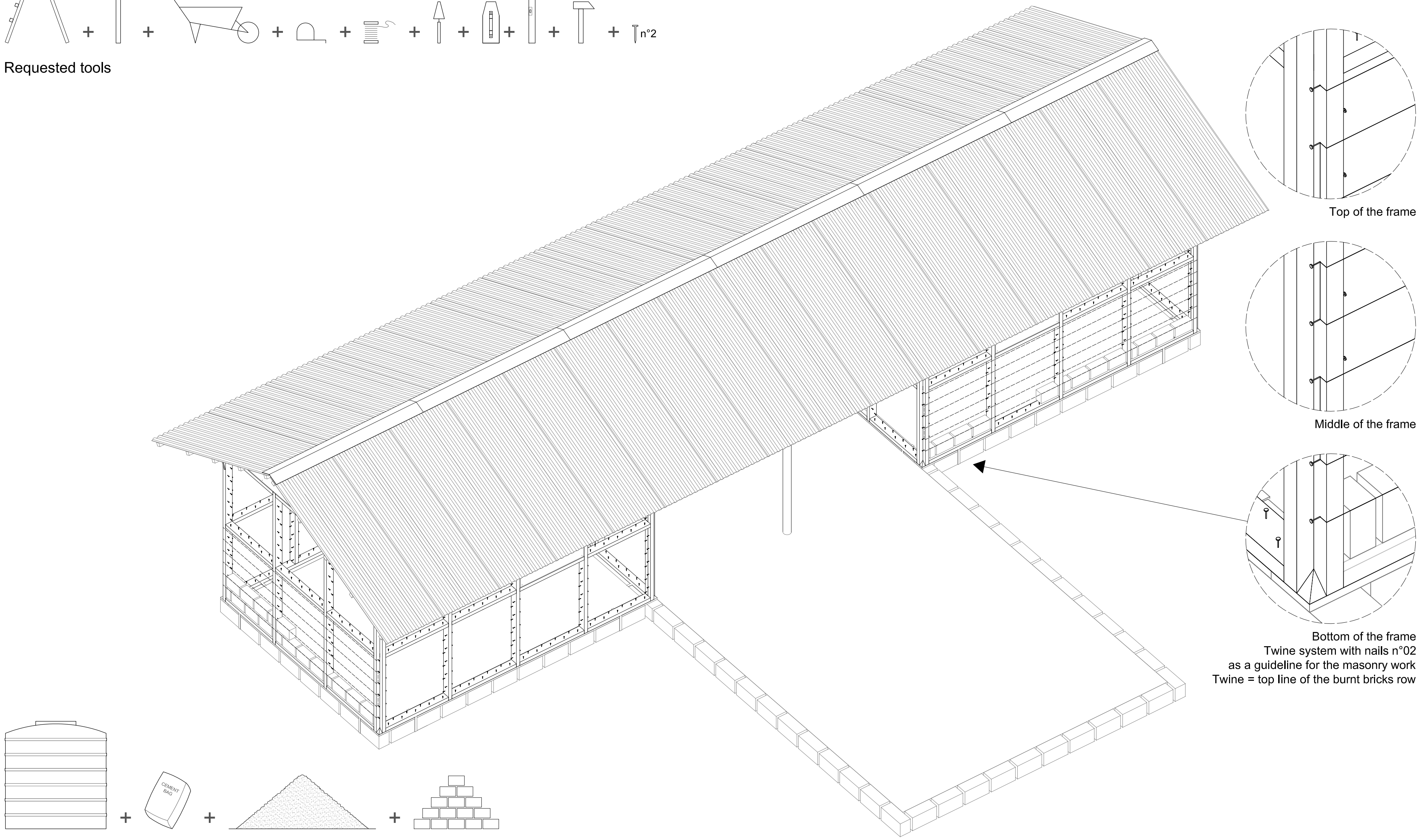


Requested tools



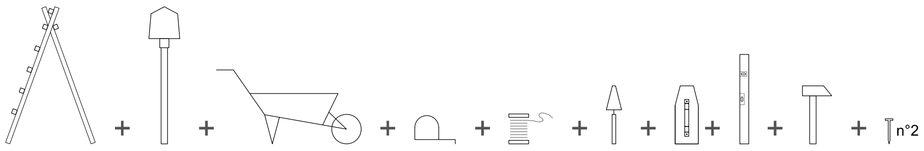
Nails n°02 every 10cm in staggered rows inside the timber frames to ensure that the mortar will stick to the wood

Burnt bricks. Preparation

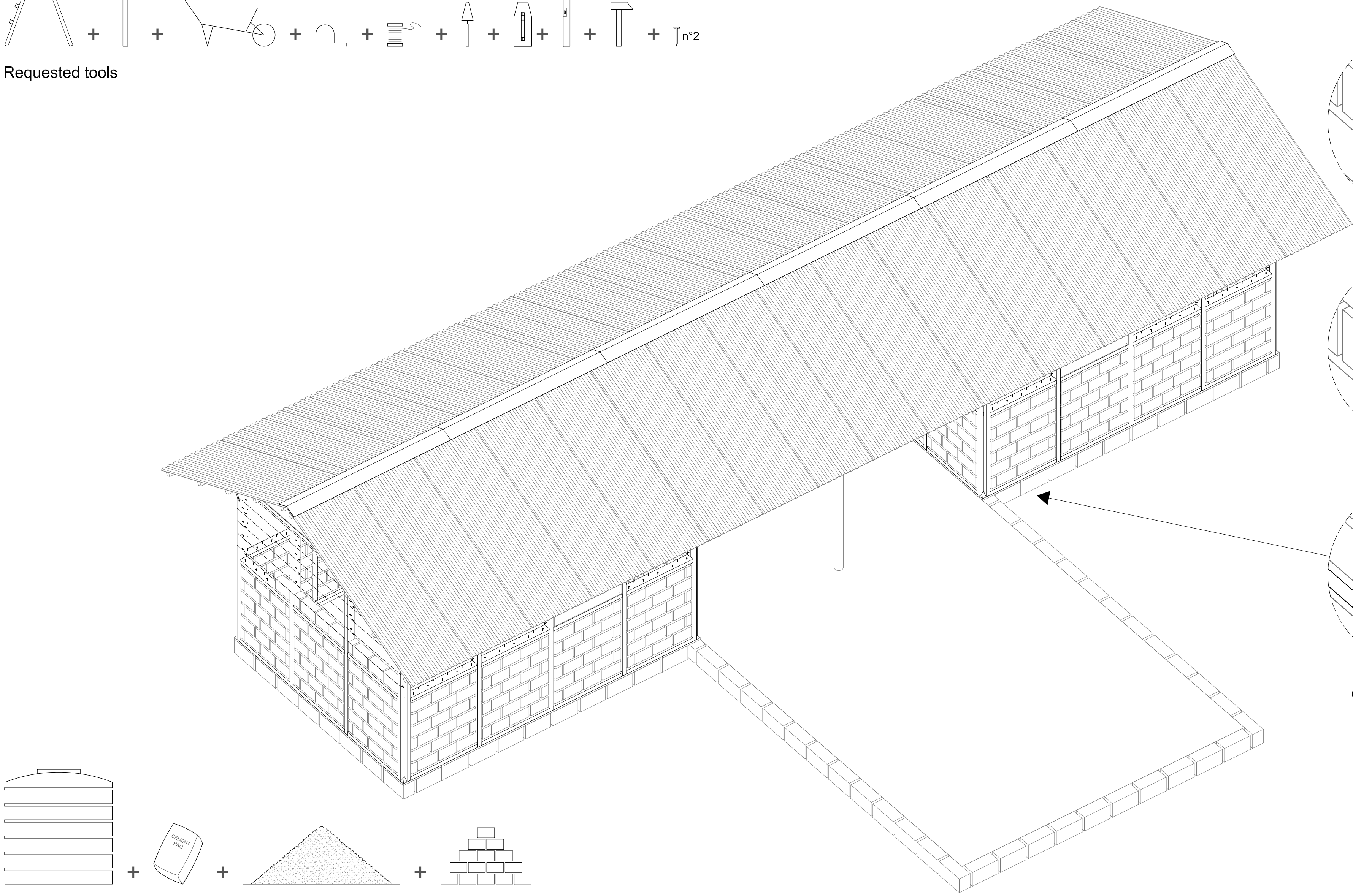


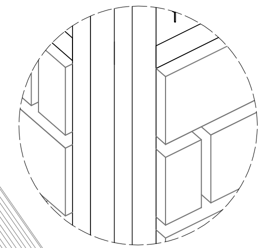
Burnt bricks. Placing the bottom rows

Assembly. 49

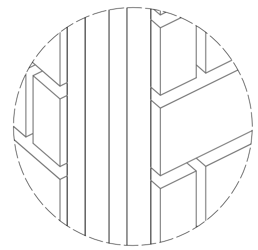


Requested tools

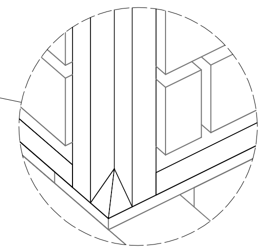




Top of the frame



Middle of the frame



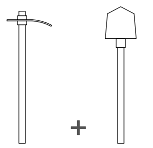
Bottom of the frame
Close-up on the burnt bricks

Requested material

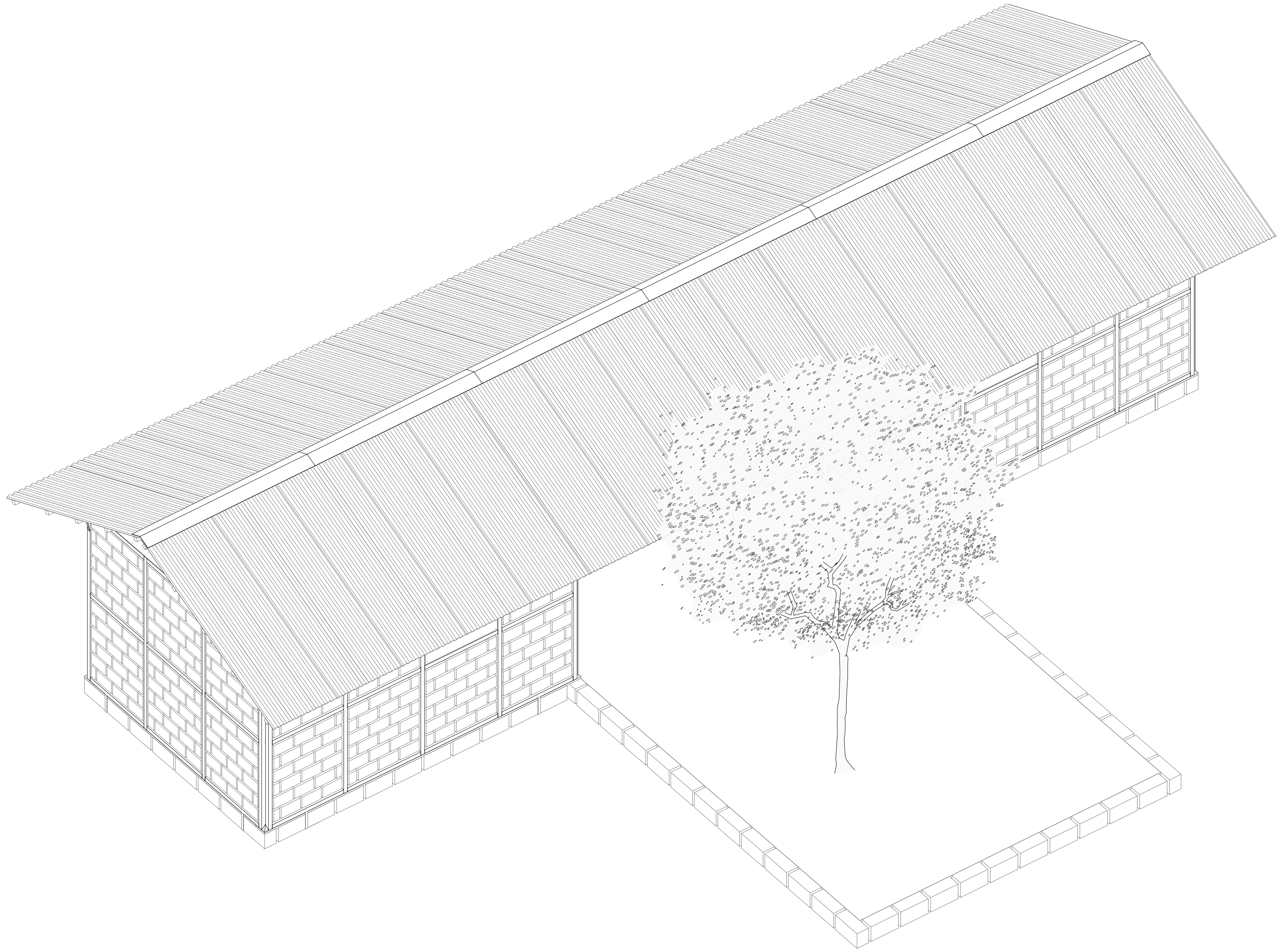
Burnt bricks. Placing the top rows

House B3 Manual

Assembly. 50

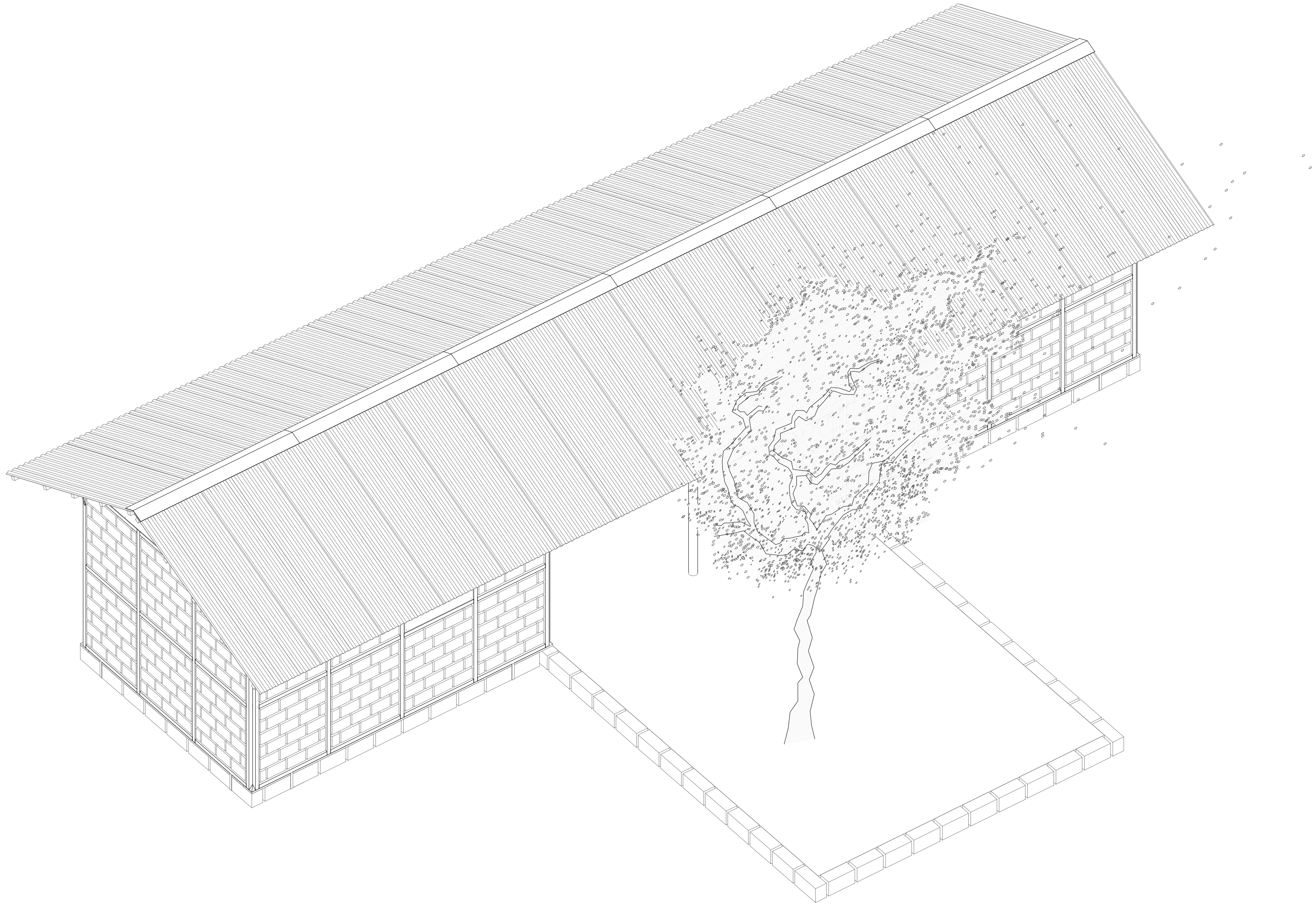


Requested tools



Tree planting

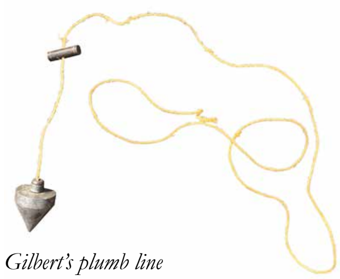
Assembly. 51



A few years later...in a windstorm

1/2. A Few of the Tools Used for House B3 Construction *(non-exhaustive, no-scale)*

Container used to carry water for mortar mix



Gilbert's plumb line Very useful for masonry work

Mace with a handmade rubber handle

Cup. Used to dig holes for Prosopis poles

Scissors to cut metal sheets

Chisel for cutting stones

Spade for foundation trenches

Wood saw customized with a handmade plastic handle and roofnails

Metal shovel

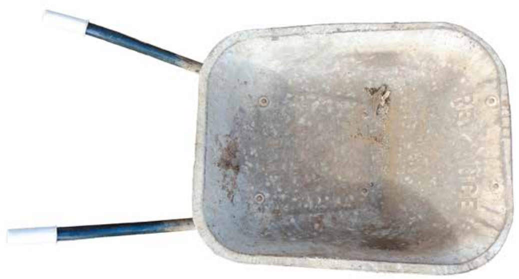
Handmade rack with reinforcing bars welded to a metal plate

Very old tape measure used for measurement

Nail used as a cutter

'Panga' with a goat-skin handle For wood shaping, metal sheet cutting...

'Panga' in a bad shape. Used to scape excess mortar off the bricks



Weelbarrow for material transport and mixing mortar

Twine for alignment of foundations, timber frames, trusses, purlins, bricks...

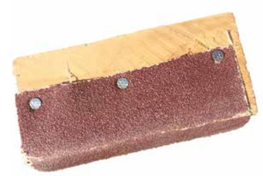
Ladder from Gilbert. His grand-father taught him how to build it with a few nails and a few pieces of wood.

2/2. A Few of the Tools Used for House B3 Construction *(non-exhaustive, no-scale)*

Pencil
from Nairobi

Rubber mallet
made from a rubber tyre

Watering can customized
for portable water suply



Sanding block made with available
nails, wood and sand paper

Used brush
for termite treatment

Sedar's plane
Precious tool

Sedar's level. Precious tool

Iron bar. Used to dig holes for Prosopis poles

Watering can, for weeting ballast before
cementing the floors

Typical hammer
from Kakuma

Set of nails (n°2, 3, 4, and 5)
No scews available in town

Wood file
with handmade rubber handle

'The fridge'. Felt around an ordinary
plastic bottle to wet and exposed to
wind for fresh water

Fork. The handle has been shaped with a 'panga'

Trowel
made with available nails and wood

Pliers
for bending wire and hoop irons

Post
for marking

Turkana Houses

In June 2015, Kalobeyei New Settlement was established, in Turkana, Kenya. UN-Habitat was tasked with designing an Advisory Development Plan for the settlement, to accommodate 60,000 people – both refugees and host community members.

In April 2017, UN-Habitat contacted Shigeru Ban, a world-renowned architect famous for his disaster relief projects, with the idea of developing shelters in Kalobeyei New Settlement. In July, an agreement of cooperation was signed between UN-Habitat, and the Voluntary Architects Network (VAN), Shigeru Ban's NGO, for the pilot programme of Shelter Typology Designs in the settlement. By August 2019, 14 houses had been constructed after testing seven housing types in the New Settlement.

The first part of the book is a journal by Philippe Monteil, Shigeru Ban's partner for the mission. It describes successes and failures with building pilot houses, and the influence of the context in the process. The second part is the visual interpretation of that process, detailed Manual which explains in a sequence across pages, how to build the final housing prototype. In summary, the book tells the story of an encounter between an architect, refugees and Turkana people, brought together through the act of building.

UN-HABITAT
FOR A BETTER URBAN FUTURE

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HS number: HS/050/20E
ISBN number: 978-92-1-132873-8